IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF DELAWARE

BRIDGESTONE SPORTS CO., LTD. and
BRIDGESTONE GOLF, INC.,
Plaintiffs,

v.

ACUSHNET COMPANY,
Defendant.

C.A. No. 05-132 (JJF)

**REDACTED –
PUBLIC VERSION**

BRIDGESTONE'S REPLY BRIEF IN SUPPORT OF ITS MOTION FOR SUMMARY JUDGMENT OF NO INVALIDITY OF U.S. PATENT NO. 5,743,817

MORRIS, NICHOLS, ARSHT & TUNNELL LLP
Jack B. Blumenfeld (#1014)
Leslie A. Polizoti (#4299)
1201 N. Market St.
P.O. Box 1347
Wilmington, DE 19801
(302) 658-9200

*Attorneys for Bridgestone Sports Co., Ltd.
and Bridgestone Golf, Inc.*

OF COUNSEL:

Robert M. Masters
Scott M. Flicker
PAUL, HASTINGS, JANOFSKY & WALKER LLP
875 15th St., N.W.
Washington, DC 20005
(202) 551-1700

Originally Filed: May 11, 2007
Redacted Version Filed: May 16, 2007

TABLE OF CONTENTS

TABLE OF AUTHORITIES

Cases

INTRODUCTION

Acushnet has the burden of showing by clear and convincing evidence that JP '673 invalidates claim 1 of the '817 Patent. Acushnet chose to advance an invalidity argument based on what it contends to be the inherent disclosure of JP '673. Thus, Acushnet must show that the feature it contends to be inherent – a ratio of core to ball distortion – must be present in JP '673, not that it is possibly or probably present. Acushnet cannot do so, because its evidence does not represent the actual disclosure of JP '673. Thus, Bridgestone is entitled to summary judgment of no invalidity.

ARGUMENT

A. Acushnet's Anticipation Arguments Are Unsupported

Bridgestone asserts claim 1 of the '817 patent, which recites, *inter alia*: (1) a core with "a distortion of 2.9 to 4.0 mm under a load of 100 kg"; and (2) that "the ratio of a core distortion under a load of 100 kg divided by a ball distortion under a load of 100 kg ranges from 1.0 to 1.3."

In his invalidity expert report, Dr. Felker asserts that claim 1 of the '817 Patent is anticipated by JP '673. (D.I. 352, Ex. 3 at 26). He opines that JP '673 expressly discloses many of the claimed features, but concedes that it "does not explicitly disclose the ratio of core distortion divided by ball distortion, or the Shore D hardness of the cover." (*Id.* at 27). To overcome this deficiency, Dr. Felker asserts that these features are inherent[1] properties of the exemplary golf balls disclosed in Table 4 of JP '673. (*Id.* at 27, 28).

---

1 To show an inherent disclosure, the extrinsic evidence "must make clear that the missing descriptive matter is necessarily present in the thing described in the reference, and that it would be so recognized by persons of ordinary skill." *Continental Can Co. v. Monsanto Co.*, 948 F.2d 1264, 1268 (Fed. Cir. 1991). Inherency "requires that the missing descriptive material is 'necessarily present,' not merely probably or possibly present."

(continued...)

Dr. Felker says that JP '673 "teaches how to construct" such balls and specifically cites its disclosure that, to form the balls of Table 4:

> Solid cores were prepared by combining 100 parts by weight of polybutadiene, 20 to 80 parts by weight of zinc oxide, 10 to 30 parts by weight of acrylic acid and 0.5 to 4 parts by weight of dicumylperoxide, milling the compositions in a 1000α Banbury mixer and a roll mill, and compression molding them at 150°C [302°F] for 40 minutes.

(D.I. 352, Ex. 3 at 28).

Dr. Felker then indicates that, "[a]cting under my supervision, Acushnet employees **used those teachings** to construct golf ball cores" (D.I. 352, Ex. 3 at 29), emphasis added) and then "used a 1.75 mm thick cover" to form a ball (*id.*). Acushnet's engineers, however, did not do what Dr. Felker said. They did not follow the teachings of JP '673 to form the core or the resultant ball. Instead, Acushnet's engineers chose to:

- use Polywate 325, which is a barium sulfate ($BaSO_4$) filler, in the cores (D.I. 352, Ex. 3 at 29-30), despite the fact that this ingredient is not disclosed as being used in the cores of Table 4 of JP '673;

- use 0.5-0.6 parts by weight of Trigonox 265 – which is equivalent to only about 0.25 to 0.3 parts by weight of peroxide (*id.*), rather than JP '673's specification of 0.5 to 4 parts by weight of peroxide;

- mold the cores at a temperature of 335°F for 11 minutes (*id.* at 30), rather than JP '673's specification of 150°C (302°F) for 40 minutes; and

- form balls that are not even close to meeting United States Golf Association (USGA) or any other international requirements.

Dr. Felker did not address whether any of these changes substantively affect the properties of the cores and golf balls made by the Acushnet engineers – as compared to cores and

(...continued)

Trintec Indus., Inc. v. Top-U.S.A. Corp., 295 F.3d 1292, 1295 (Fed. Cir. 2002) (citations omitted). The mere fact that "a certain thing may result from a given set of circumstances is not sufficient" to show inherency. *In re Robertson*, 169 F.3d 743, 745 (Fed. Cir. 1999) (citations omitted).

golf balls actually made according to the specific disclosure of JP '673. Dr. Felker cannot deny, however, that these changes have an effect, because he says in his non-infringement expert report that very slight changes in core composition have dramatic effects on physical characteristics of cores. (D.I. 352, Ex. 3 at 98, ¶ 361).

Because of all of these deviations, Acushnet cannot argue that the Acushnet-prepared balls actually have the inherent features of the balls of Table 4 of JP '673.

B. Acushnet's Obviousness Arguments Are Unsupported

Dr. Felker also asserts that, even if JP '673 does not inherently disclose the limitation of the claimed ratio of core distortion divided by ball distortion, it "would have been obvious to one of ordinary skill in the art." (D.I. 352, Ex. 3 at 37). To support this, Dr. Felker does nothing more than cite "basic" physics and make a conclusory statement that the claimed distortion ratio was provided in Bridgestone's EV Extra Spin golf ball and another reference, GB '628 - and therefore would have been obvious. (*Id.* at 37, 38). This is not a proper obviousness analysis. It is unclear whether Dr. Felker asserts that these additional references are used in combination with JP '673, in place of JP '673, or some variation thereof. Also, Dr. Felker does not identify the differences between the claimed invention and the prior art. *In re Dembiczak*, 175 F.3d 994, 998 (Fed. Cir. 1999). The claimed invention is analyzed as a whole – not in a piecemeal fashion by looking only for the core distortion in other references.

Further, despite Acushnet's arguments to the contrary (D.I. 411 at 9), this obviousness assertion was not included in any specific contention in Acushnet's final invalidity contentions. It is therefore improperly included in Dr. Felker's report.[2]

---

2 Acushnet cites a portion of a response to a different interrogatory (Bridgestone Interrogatory 5). However, this language lacks specificity, and is not in response to Bridgestone's invalidity contention interrogatory no. 4. (D.I. 352, Ex. 2 at 49).

C. Acushnet's Arguments Are Irrelevant And Inaccurate

Instead of addressing Bridgestone's arguments directly, Acushnet attempts to muddy the record with attorney argument. None of Acushnet's arguments compel a conclusion that Bridgestone is not entitled to summary judgment.

1. Dr. Felker's Report Indicates That He Directed The Engineers To Make Cores According To The Specific Instructions Of JP '673 – Not Just To Meet A Test Result

Acushnet first argues that Dr. Felker did not direct the Acushnet engineers to make cores according to the recipe in JP '673, but simply to meet the core distortions of Table 4. (D.I. 411 at 6).

This argument is contrary to Dr. Felker's report. As discussed above, Dr. Felker quoted the specific recipe and molding instructions of JP '673. (D.I. 352, Ex. 3 at 28). He then states that "[a]cting under my supervision, Acushnet employees used those teachings to construct golf ball cores." (*Id.* at 29). He then undertakes a two-page explanation of the different ingredients the Acushnet engineers selected for use in the cores, and explains why zinc diacrylate and acrylic acid are interchangeable.

2. Just Because The Cores Made By Acushnet's Engineers Have The Distortion Of Table 4 Does Not Mean They Were Made According To JP '673

Acushnet next argues that, because the engineers made cores that have the distortions of Table 4, that these cores reflect the inherent disclosure of JP '673. (D.I. 411 at 6, 7). But just because the cores Acushnet's engineers made happen to have similar core distortions, that does not mean they reflect the inherent teachings of JP '673.[3]

---

3 Acushnet also argues that "[t]here is no dispute that the golf ball cores constructed by Acushnet's engineers possessed [the] distortions" specified in Table 4. (D.I. 411 at 4). This is incorrect. There is a significant dispute - because Acushnet utilized an incorrect (continued...)

It is undisputed that Acushnet's engineers changed two ingredients, changed the molding time, and made non-regulation golf balls – all without any explanation either in Dr. Felker's report or now in response to Bridgestone's motion. Thus, there are no facts that demonstrate that the cores made by Acushnet's engineers are equivalent to those of Table 4 of JP '673.[4]

3. Dr. Felker's Use Of The Test Results Is Improper

Acushnet next argues that Bridgestone has not shown that the deviations by Acushnet's engineers "are relevant to Dr. Felker's analysis or conclusions." (D.I. 411 at 7). Dr. Felker is relying on test results of the cores made by the Acushnet engineers to opine that the '817 Patent is invalid. Because those cores are not reflective of the inherent properties of JP '673, Dr. Felker's entire opinion with respect to the '817 Patent falls apart.

4. It Is Not Bridgestone's Burden To Show That Acushnet's Engineers' Deviations Had No Effect

Acushnet next argues that Bridgestone has not come forward with evidence that the decisions of Acushnet's engineers "made any impact on Dr. Felker's analysis or conclusions." (D.I. 411 at 7). It is not Bridgestone's burden, however, to show that the cores

(...continued)

cross-head speed in its testing (in addition to using cores and balls unrepresentative of JP '673), as explained by Bridgestone's expert, Dr. Caulfield, in his expert report. (Ex. 1 at 7, ¶ 15).

4 The case cited by Acushnet, *Glaxo v. Novopharm*, is not on point. In *Glaxo*, the district court found that one of ordinary skill would understand that the tests run by *Glaxo*'s experts were the same as those of the patent at issue. *Glaxo Inc. v. Novopharm Ltd.*, 52 F.3d 1043, 1047 (Fed. Cir. 1995). However, that is impossible here, because no Acushnet expert has opined that one of ordinary skill would believe the deviations of Acushnet's engineers to be insignificant to the test results.

Acushnet's engineers made are not the same as those of JP '673.[5] It is Acushnet's burden to show the reference it is relying on is prior art. *See Mahurkar v. C.R. Bard, Inc.*, 79 F.3d 1572, 1576 (Fed. Cir. 1996). Here, the cores made by the Acushnet engineers are not the same as JP '673. Thus, Acushnet cannot meet its burden to show that the cores made by the Acushnet engineers are representative of any prior art.

5. The Effect Of The Deviations Does Not Raise A Material Fact That Would Prevent Bridgestone From Obtaining Summary Judgment

Acushnet next contends that Bridgestone's criticisms raise "questions of fact" that would prevent summary judgment. (D.I. 411 at 7). To avoid summary judgment, however, these facts must be "material." *See Boyle v. County of Allegheny*, 139 F.3d 386, 393 (3d Cir. 1998).

The undisputed material facts here are that JP '673 has a specific disclosure of core ingredients and molding steps, that Acushnet's engineers deviated from this disclosure, and that none of Acushnet's experts argued that these deviations are insignificant. Thus, Acushnet cannot rely on the cores made by its engineers to show any inherent property of JP '673 – because Acushnet cannot establish a link between what is shown in those cores and what is disclosed in JP '673.

---

[5] The case cited by Acushnet, *Astra v. Andrx*, is not on point. In *Astra*, the district court found that the patentee had admitted that a claimed feature was inherently present in the prior art. *Astra Aktiebolag v. Andrx Pharms., Inc.* (In re Omeprazole Patent Litig.), 2007 U.S. App. LEXIS 9233, *20 (Fed. Cir. 2007). That is not the case here.

6. JP '673 Does Specify Ball And Core Diameters And Weights, But Acushnet's Engineers Ignored Them

Acushnet next contends that JP '673 does not require balls to be made according to USGA or international regulations. This is incorrect. JP '673 discloses parameters of "golf balls" (D.I. 352, Ex. 5 at p 401 (2 of 2)) and that these golf balls are of "small size" and "large size." "Small size" and "large size" were commonly used in the industry throughout the 1980s and 90s to specify regulation golf balls that have: (1) a diameter of at least 41.15 mm (an old British regulation); or (2) a diameter of at least 42.67 mm (the current USGA regulation), respectively.[6] In both cases, the maximum weight of the small and large balls is 45.92 g (the USGA standard). It is undisputed that Acushnet's golf balls meet neither of these regulations.

Balls made by Acushnet's engineers are far outside of regulation. The balls of sample set nos. 1 and 2 have a finished diameter of 39.5 mm (1.55 inches), which is 3.17 mm less than the 42.67 mm minimum for large balls, and 1.65 mm less than the 41.15 mm minimum for small balls. (D.I. 352, Ex. 3 at 32, 33). The balls of sample set nos. 3 and 4 have weights of 48.9 to 49.9 g, which is approximately 4 grams heavier than the 45.93 g maximum weight for both small and large balls. (*Id.*, Ex. 9 at Tab 54).

---

6 *See, e.g.*: (1) US 4,681,323 – Ex. 2, col. 3:47-51 ("small balls having a diameter of not less than 41.15 mm and a weight of not more than 45.92 g and large balls having a diameter of not less than 42.67 mm and a weight of not more than 45.92 g."); (2) US 4,929,678 – Ex. 3, col. 2:53-55 ("A golf ball is standardized by JIS S-7005-1955 to a diameter of at least 42.67 mm for large size or at least 41.15 mm for small size."); (3) US 5,009,428 – Ex. 4, col. 4:9-10 ("small balls having a diameter of at least 41.15 mm and a weight of up to 45.92 g, and large balls having a diameter of at least 42.67 mm and a weight of up to 45.92 g"); and (4) US 5,087,049 – Ex. 5, col. 4:64-68 ("It should be appreciated that the balls include both small balls having a diameter of at least 41.15 mm and a weight of up to 45.92 g, and large balls having a diameter of at least 42.67 mm and a weight of up to 45.92 g."). There are many more examples.

CONCLUSION

Bridgestone requests that its motion for summary judgment that claim 1 of the '817 Patent is not invalid be granted.

MORRIS, NICHOLS, ARSHT & TUNNELL LLP

/s/ Leslie A. Polizoti

Jack B. Blumenfeld (#1014)
Leslie A. Polizoti (#4299)
1201 N. Market St.
P.O. Box 1347
Wilmington, DE 19801
(302) 658-9200
Attorneys for Bridgestone Sports Co., Ltd. and Bridgestone Golf, Inc.

OF COUNSEL:

Robert M. Masters
Scott M. Flicker
PAUL, HASTINGS, JANOFSKY & WALKER LLP
875 15th St., N.W.
Washington, DC 20005
(202) 551-1700

May 11, 2007
825348

CERTIFICATE OF SERVICE

I certify that on May 11, 2007 I electronically filed the foregoing with the Clerk of the Court using CM/ECF, which will send notification of such filing(s) to Richard L. Horwitz and David E. Moore.

I further certify that I caused copies to be served upon the following on May 11, 2007 in the manner indicated:

BY E-MAIL & HAND

Richard L. Horwitz, Esquire
POTTER ANDERSON & CORROON LLP
1313 N. Market Street
Wilmington, DE 19801

BY E-MAIL & FEDERAL EXPRESS

Joseph P. Lavelle, Esquire
HOWREY LLP
1299 Pennsylvania Avenue, NW
Washington, DC 20004

/s/ Leslie A. Polizoti
Leslie A. Polizoti (#4299)
MORRIS, NICHOLS, ARSHT & TUNNELL LLP
Wilmington, DE 19801
(302) 658-9200
lpolizoti@mnat.com

EXHIBIT 1

IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF DELAWARE

BRIDGESTONE SPORTS CO. LTD., AND BRIDGESTONE GOLF, INC Plaintiff, v. ACUSHNET COMPANY Defendant.	Case No. 05-132(JJF)
ACUSHNET COMPANY Counterclaim-Plaintiff, v. BRIDGESTONE SPORTS CO. LTD., AND BRIDGESTONE GOLF, INC Counterclaim-Defendant.	

EXPERT REPORT OF EDWARD M. CAULFIELD, Ph.D., P.E.

EXPERT REPORT OF EDWARD M. CAULFIELD

TABLE OF CONTENTS

EXPERT REPORT OF EDWARD M. CAULFIELD

TABLE OF EXHIBITS

EXPERT REPORT OF EDWARD M. CAULFIELD

I. INTRODUCTION

1. I, Edward M. Caulfield, Ph.D., P.E. am President and Chief Technical Officer of Packer Engineering, Inc., a multi-disciplinary engineering consulting and technical services company with locations in Naperville, Illinois, Cincinnati, Ohio, Washington D.C., and Ann Arbor, Michigan. I submit the following report to explain why the deformation rate of 20 in/min utilized in the Packer Engineering 100 kg load testing of the golf balls more accurately predicts the golf ball's elastic modulus than the deformation rate of 1 in/min used in the testing by Acushnet's expert Dr. David Felker.

2. As stated in my initial report dated January 15, 2007, I have been retained in this matter to evaluate golf balls manufactured by the Defendant, Acushnet, in connection with US patents 5,262,652; 5,553,852; 5,743,817; 5,782,707; 5,803,834; 6,634,961; and 6,679,791 (held by Bridgestone Sports Co,. LTD) in conjunction with an investigation of patent infringement issues. Packer Engineering is charging my normal hourly rate of $475.00/hour for my time spent in this matter and neither Packer Engineering, nor I, have any financial or other interest in the outcome of this case or in any of the parties to this action.

3. My qualifications and background were discussed in my initial report and can be found in my CV which was attached as Exhibit EX-1 to my initial report. Based on my education, training, knowledge of the literature, and professional experience, I am fully competent to testify regarding the subject matters of, among other things, the material

properties and material property testing of golf balls including those material properties described and claimed in the patents at issue in this matter.

4. Kevin L. Jones, a Senior Staff Consultant at Packer Engineering with a B.S. in Metallurgical and Materials Engineering, assisted with the evaluation and analysis of the golf balls studied in this investigation.

II. MATERIALS CONSIDERED

5. In addition to information as a result of my general background and experience, I have reviewed and asked my engineering staff to help in the review of materials relating to the patents-in-suit and testing standards as listed in Exhibits EX-2 and EX-3 in my initial report as well as the material contained in the exhibits attached to this report and the report of Acushnet's expert Dr. David Felker dated January 16, 2007.

III. COMPRESSION TESTING DISPLACEMENT RATE

6. As stated in the Test Protocol for Ball and Core Compression under 100 kg Load (Exhibit EX-7 to initial my report) a 20 inches per minute (in/min) crosshead displacement rate was utilized in the compression testing of the subject golf balls and golf ball cores. This 20 inches per minute (in/min) crosshead displacement rate for compression testing of the subject golf balls and golf ball cores was used because it would minimize viscoelastic deformation as well as yield repeatable results.

7. The 20 inches per minute (in/min) crosshead displacement rate selected for compression testing of the subject golf balls and golf ball cores was based on the strain rates experienced by golf balls in service, American Society of Testing Materials (ASTM)

EXPERT REPORT OF EDWARD M. CAULFIELD

Standard D412 – *Standard Test Method for Vulcanized Rubber and Thermoplastic Elastomers – Tension* (Exhibit EX-36), as well as my education, training, and professional experience and additional factors including an article by Jeff Dalton of Acushnet Company titled "*Compression by Any Other Name*", published in Science and Golf IV (Exhibit EX-37).

8. In the article "Compression by Any Other Name" Mr. Dalton of Acushnet Company discusses numerous compression testing methods used in the golf ball industry. In particular, Mr. Dalton discusses the Atti and Riehle Compression testing. In the article Mr. Dalton states the Atti Compression test has deformation rates between 4 in/min and 40 in/min while the Riehle Compression test has a deformation rate of approximately 5 in/min. Mr. Dalton indicates the fundamental property being measured in these different tests is the elastic modulus and attempts to correlate these test methods to load versus displacement results obtained from a compression/testing machine. Although, Mr. Dalton utilized a crosshead speed of approximately 1 in/min in his own testing, this paper illustrates Acushnet was aware that faster deformation rates were historically used in the golf ball industry to evaluate the elastic modulus of golf balls using a compression test.

9. The elastic modulus of a linear elastic material, such as most metallic or ceramic materials, is typically defined as

$$\sigma = E\varepsilon$$ (Hooke's Law) (Ref. Exhibit EX-38)

Where σ is the stress, ε is the strain (deformation) and E is the elastic modulus.

EXPERT REPORT OF EDWARD M. CAULFIELD

10. Currently, golf ball cores are manufactured from "elastomer" materials. Due to their complex structures, elastomer materials may exhibit both an elastic and a viscous response to the application of a load. This combined elastic and viscous response is referred to as viscoelasticity. Viscoelastic materials deform by two mechanisms under an applied force. These two mechanisms are:

    1) An instantaneous, time independent, deformation due to the applied load (Elastic deformation).

    2) Time dependent viscous deformation.

11. Numerous attempts have been made to model the response of polymers and elastomers under an applied load. Two widely accepted model components are the Voigt and Maxwell models (See e.g. Exhibits EX-38 and EX-39).

$$\sigma = \mathrm{E}\varepsilon + \eta \frac{d\varepsilon}{dt} \qquad \text{(Voight Model)}$$

$$\frac{\sigma}{\eta} = \frac{d\varepsilon}{dt} - \frac{1}{\mathrm{E}}\frac{d\sigma}{dt} \qquad \text{(Maxwell Model)}$$

Both the Voigt and Maxwell models utilize a spring to represent the time independent elastic strain (Hookean behavior) and a dashpot to represent the time dependent viscoelastic deformation. A dashpot is simply a damping mechanism which resists motion via friction. An example of a dashpot is a hydraulic door closing mechanism typically found on screen doors. In both models, as the duration of the load application

increases, the amount of time dependent (viscoelastic) deformation increases. Similarly, with rapid rates of load application, the dashpot representing the time dependent deformation does not contribute to the total deformation – only the elastic (Hookean) spring contributes to the material's total deformation. This can be visualized by trying to close your "dashpot" door quickly. If one tries to close the door rapidly, the door resists the force and does not close because of the time dependent motion of the closing mechanism.

12. With respect to the determination of the elastic modulus of a golf ball, the time dependent deformation can be minimized with higher deformation (strain) rates. This is illustrated schematically in Exhibit EX-40, Figure 1, which shows a comparison of the deformation for the 100 kg compression test for crosshead displacement rates of 20 in/min and 1 in/min. As the cross-head speed increases, the deformation at a particular load decreases due to the decrease in the time dependent strain.

13. Accurate measurement of a golf ball's elastic modulus can only be determined by performing the test at relatively fast deformation rates to decrease the amount of time dependent deformation. The impact event experienced by a golf ball in service occurs over a very short time interval and very little time dependent deformation would be able to occur during this impact event. An article and report by Dr. Steve Quintavalla, Ph. D., a Research Engineer at the United States Golf Association (USGA) Test Center, indicates the average golfer has a driver club speed of 90 mph (Exhibits EX-41 and EX-42). A club speed of 90 mph translates to a velocity of approximately 95,000 in/min. Another

article on the USGA website states "a golf ball remains in contact with the club face for only about 450 microseconds (0.00045 sec)" (Exhibit EX-43). Clearly, very little time dependent strain can occur between the ball and club face during this impact event. Therefore, in order to accurately determine a golf balls elastic modulus, a relatively fast deformation rate is required. Mr. Dalton failed to properly address the viscoelastic nature of the golf ball material in his paper and did not mention that the elastic modulus of these polymer materials is time dependent due to their inherent viscoelastic behavior.

14. Based on how deformation (strain) rate affects the viscoelastic behavior of polymers, and basic knowledge on golf club speeds, a deformation rate which would limit the amount of time dependent (viscoelastic) strain is required. ASTM D412 - *Standard Test Method for Vulcanized Rubber and Thermoplastic Elastomers – Tension,* specifies that tensile samples prepared from rubber (a viscoelasctic material) must be tested at 20 ±2 in/min. This crosshead displacement rate of 20 in/min specified in this ASTM standard was used for the testing done at Packer Engineering because it would minimize viscoelastic deformation as well as yield repeatable results. Further, the ASTM D412 test standard has been in existence for over 80 years (date of issue 1935) and this deformation rate is easily achievable on standard test equipment. Finally, the use of 20 in/min is further justified by Mr. Dalton's paper when he discusses deformation rate for the Atti Compression test. The deformation rate range specified for the Atti Compression test is 4 in/min to 40 in/min and a cross head speed of speed of 20 in/min is near the midpoint of this deformation rate range.

EXPERT REPORT OF EDWARD M. CAULFIELD

15. Therefore for all the reasons stated above, the crosshead displacement rate of 20 in/min was utilized in the Packer Engineering 100 kg load compression testing of the golf balls and it more accurately predicts the golf ball's elastic modulus than the deformation rate of 1 in/min used in the testing by Acushnet's expert Dr. David Felker.

IV. CONCLUSION

16. I hereby declare under penalty of perjury that all of the foregoing statements are based on my personal knowledge and are true and correct to the best of my knowledge and belief. If called upon as a witness, I could and would testify competently to the matters stated in this report.

Dated: February 20, 2007

E. M. Caulfield

Edward M. Caulfield, Ph.D., P.E.
President and Chief Technical Officer

Kevin Jones

Kevin L. Jones
Senior Staff Consultant

EXHIBIT 2

United States Patent [19]

Alaki et al.

[11] **Patent Number: 4,681,323**

[45] **Date of Patent: Jul. 21, 1987**

[54] **GOLF BALL**

[75] Inventors: **Yasuhide Alaki,** Saitama; **Masayuki Ohtake,** Yokohama; **Keisuke Ihara,** Tokyo, all of Japan

[73] Assignee: **Bridgestone Corporation,** Tokyo, Japan

[21] Appl. No.: **699,438**

[22] Filed: **Feb. 7, 1985**

[30] **Foreign Application Priority Data**

Feb. 7, 1984 [JP] Japan 59-20419

[51] **Int. Cl.**[4] **A63B 37/14;** A63B 37/02

[52] **U.S. Cl.** **273/232;** 273/218; 273/227; 273/DIG. 22

[58] **Field of Search** 273/232, 220, 218, 227

[56] **References Cited**

U.S. PATENT DOCUMENTS

878,254	2/1908	Taylor	273/232
4,090,716	5/1978	Martin et al.	273/232
4,142,727	3/1979	Shaw et al.	273/232

FOREIGN PATENT DOCUMENTS

925121	4/1973	Canada	273/232
4626	1/1979	Japan	273/232
2103939	3/1983	United Kingdom	273/232

OTHER PUBLICATIONS

"The Curious History of the Golf Ball, Mankind's Most Fascinating Sphere," Horizon Press, New York, pp. 126–130.

Primary Examiner—George J. Marlo
Attorney, Agent, or Firm—Birch, Stewart, Kolasch & Birch

[57] **ABSTRACT**

A golf ball with a plurality of recessed dimples having a shape in accordance with a certain mathematical ratio on the surface thereof is disclosed. The value of the spatial volume of each dimple below a plane defined by an edge of the dimple divided by the volume of a cylinder, wherein the bottom of the cylinder is defined by the plane and the height is determined by the maximum depth of the dimple from the plane, is within the range of 0.35 to 0.43. The dimples having such a shape represent at least 90 percent of the total number of dimples on the golf ball. The maximum diameter of the dimple can be within the range of 2 to 4 mm and the maximum depth of the dimple can be within the range of 0.1 to 0.4 mm. This configuration results in a golf ball having an increased carry.

10 Claims, 15 Drawing Figures

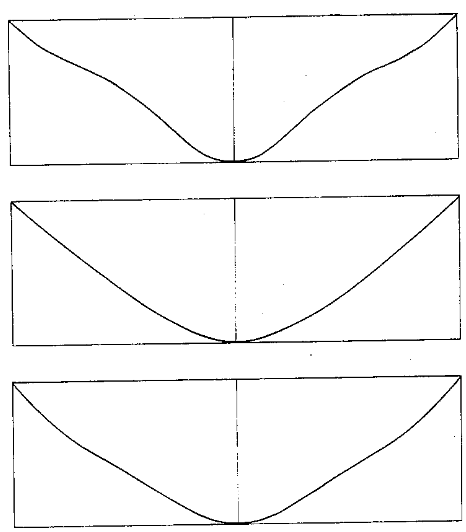


FIG.1

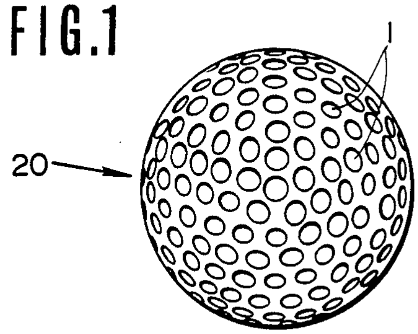


FIG.2

PRIOR ART

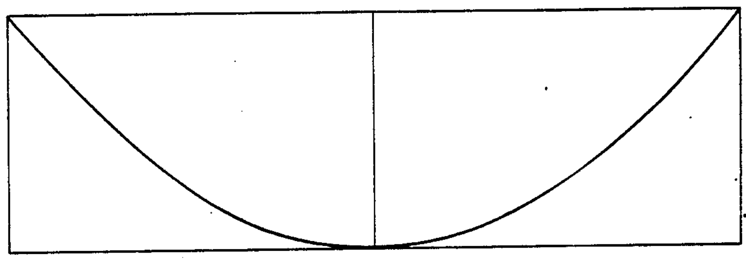


FIG.3

PRIOR ART

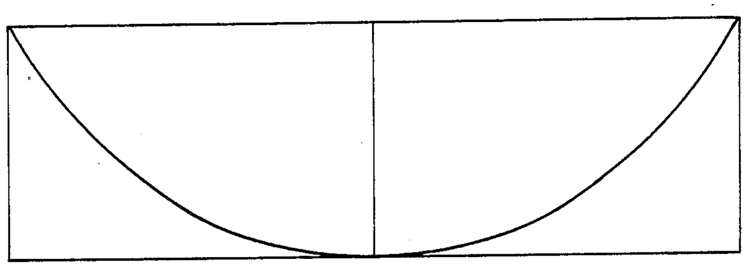


FIG.4

PRIOR ART

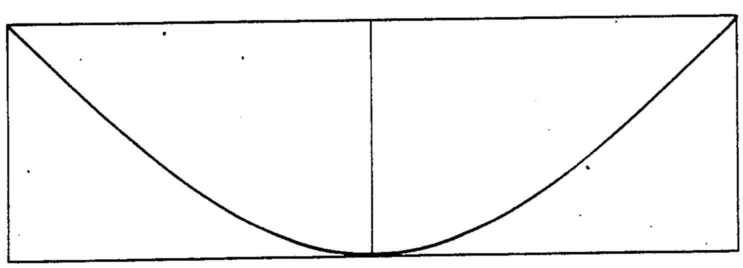


FIG.5

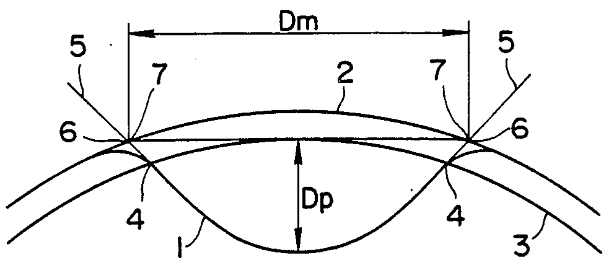


FIG.6

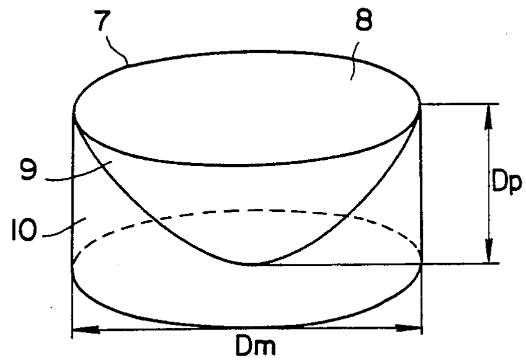


FIG.7

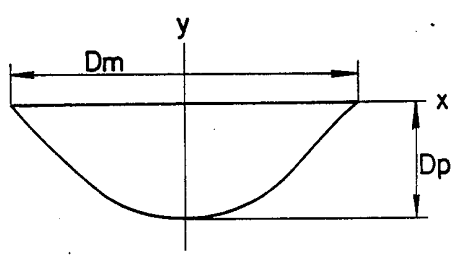


FIG. 8

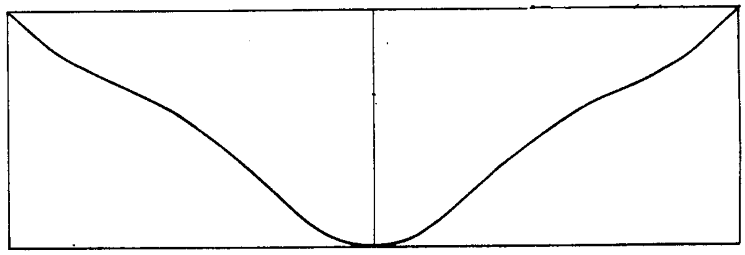


FIG. 9

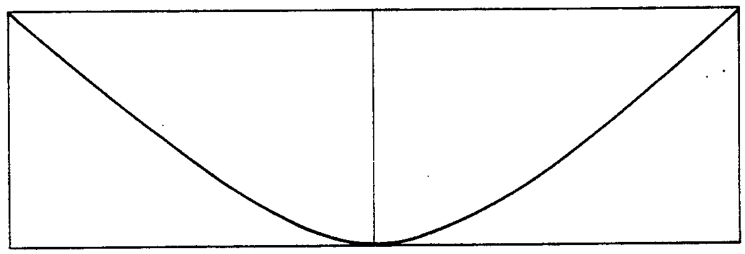


FIG. 10

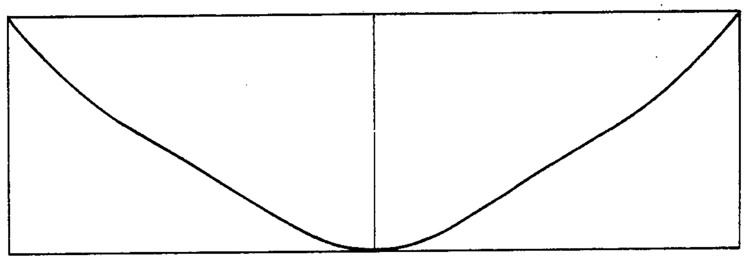


FIG. 11

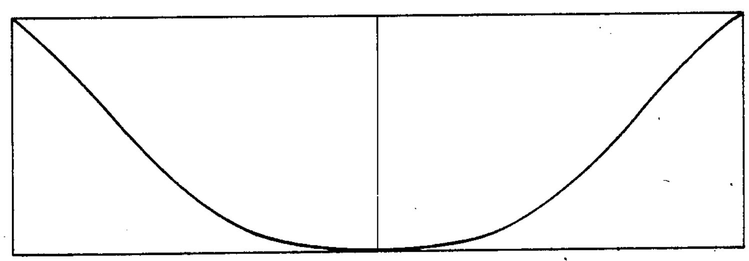


FIG. 12

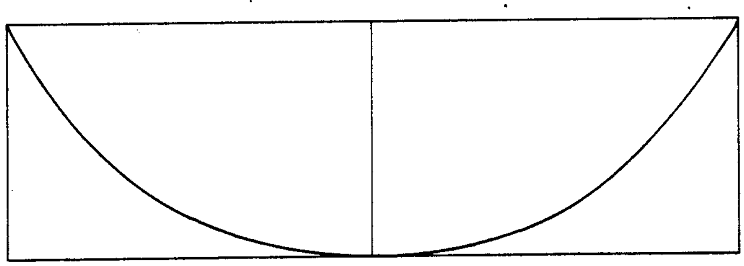


FIG.13

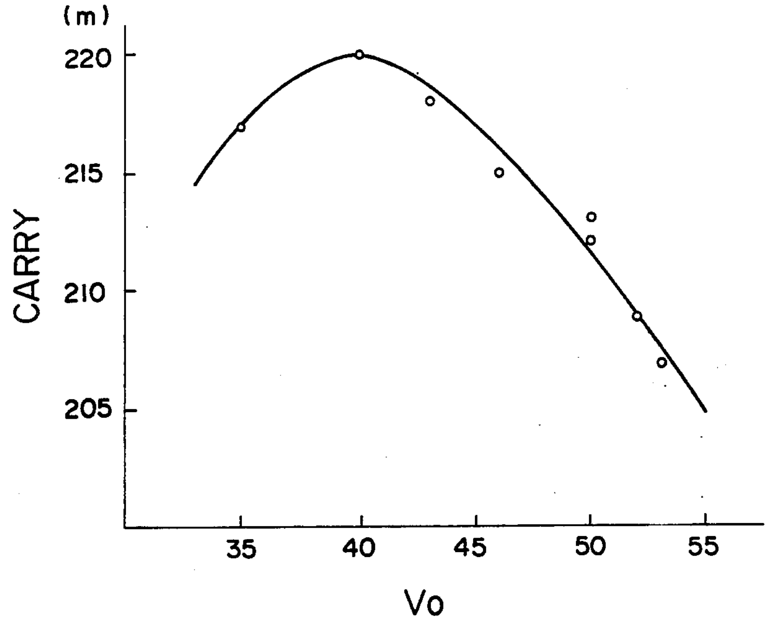

(m)
220
215
210
205
CARRY
35
40
45
50
55
Vo

FIG.14

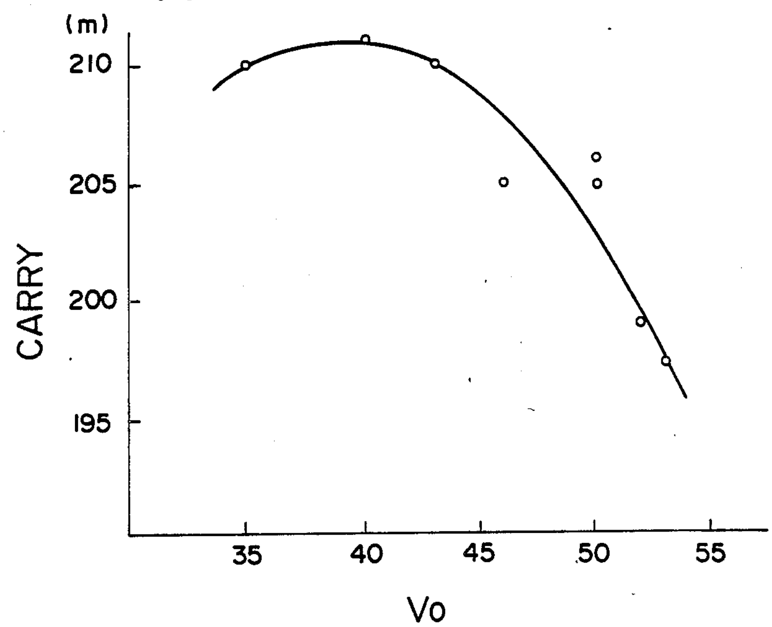
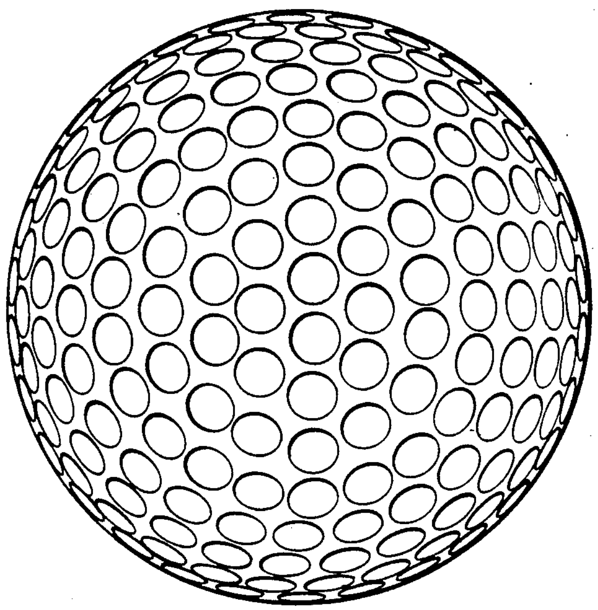

(m)
210
205
200
195
CARRY
35
40
45
50
55
Vo

FIG. 15



GOLF BALL

BACKGROUND OF THE INVENTION

This invention relates to a golf ball which has a large carry.

Conventionally, various examinations have been made to optimize an arrangement, number and size (diameter and/or depth), of dimples on a golf ball to increase the carry of a golf ball. The present inventors, however, have discovered that while such factors as the arrangement, number and size of dimples are significant factors which influence the carry of a golf ball, the sectional shape and spatial volume of a dimple are also significant.

In particular, as illustrated in FIG. 1, a golf ball 20 has a large number of recessed dimples 1 formed on the surface thereof. The shape of a dimple of such a prior art golf ball is, in most cases, a parabolic curve (FIG. 2), an ellipse (FIG. 3) or a sine curve (FIG. 4) or a flattened trapezoid. The present inventors have learned that since any of these sectional shapes sharply intrudes into the surface of the ball, the air resistance becomes aerodynamically greater in comparison with the dynamic lift and hence the ball cannot make best use of momentum initially imparted thereto, resulting in an insufficient carry of the ball. Thus, the sectional shapes of the prior art golf balls do not make sufficient use of the initial momentum.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a golf ball wherein the characteristics of dimples on the balls increase the carry of the golf ball.

After an extensive investigation in connection with developing a sectional shape and a spatial volume of a dimple on a golf ball in order to obtain a golf ball which results in an increased carry, the present inventors have discovered that dimples having such a shape that the value of the spatial volume of each dimple below a plane surrounded by an edge of the dimple divided by the volume of a cylinder wherein the bottom thereof is defined by the plane and the height is given by the maximum depth of the dimple from the plane is within the range from 0.35 to 0.43 are effective to increase the carry of a golf ball. The present inventors have also discovered that if a golf ball wherein dimples having this shape occupy at least 90 percent of the total number of the dimples on the ball, the carry increases in comparison with a golf ball having dimples having a conventional cross sectional shape.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will become more fully understood from the detailed description given hereinbelow and the accompanying drawings which are given by way of illustration only, and thus are not limitative of the present invention, and wherein:

FIG. 1 is a plan view of a golf ball;

FIGS. 2 to 4 are each cross sectional views of the dimples of a conventional golf ball;

FIGS. 5 to 7 are diagrammatic representations illustrating how to calculate the spatial volume of a dimple and the volume of a cylinder;

FIGS. 8 to 10 are cross sectional views showing different embodiments of a dimple configuration of a golf ball according to the present invention;

FIGS. 11 and 12 are cross sectional views of dimples of different golf balls of comparative examples;

FIG. 13 is a graph illustrating the carry when two piece solid balls having dimples of different shapes are hit; and

FIG. 14 is a graph illustrating the carry wherein thread-wound balls having dimples of different shapes are hit.

DETAILED DESCRIPTION OF THE INVENTION

A golf ball according to the present invention is characterized by the shape of its dimples and in that these dimples have such a shape that the value of the spatial volume of each dimple below a plane surrounded by an edge of the dimple divided by the volume of a cylinder wherein the bottom thereof is defined by the plane and the height is given by the maximum depth of the dimple from the plane is within the range from 0.35 to 0.43. The dimples have such a shape occupying at least 90 percent of the whole number of the dimples.

The shape of a dimple according to the present invention will be described more in detail. When the shape of a dimple in plan is a circle, an imaginary spherical face 2 of the diameter of the ball is drawn above a dimple 1 as illustrated in FIG. 5 while another spherical face 3 having a smaller diameter by (0.16 mm) than the ball diameter is also drawn, and cross points 4 between the spherical face 3 and the dimple 1 are found. Then, the line of cross points 6 between tangential lines 5 at the cross points 4 and the imaginary spherical face 2 is defined as a dimple edge 7. This definition of the dimple edge 7 is necessary because an accurate position of a dimple edge cannot be found without this definition since a marginal edge of a dimple 1 is normally a little rounded. Then, the first volume (V_1) of the dimple space 9 below the plane (a circle: a diameter Dm) 8 surrounded by the dimple edge 7 as illustrated in FIGS. 6 and 7 is calculated by the following equation:

$$V_1 = \int_0^{\frac{Dm}{2}} 2\pi xy dx$$

Meanwhile, the volume V_2 of the cylinder 10 wherein the bottom thereof is defined by the plane 8 and the height is defined by the maximum dimple depth Dp from the plane 8 is calculated by the following equation:

$$V_2 = \frac{\pi Dm^2 Dp}{4}$$

Then, the ratio V_o of the dimple volume V_1 to the cylinder volume V_2 is calculated by the following equation:

$$V_o = V_1/V_2$$

It is to be noted that when the shape of the dimple from a plan view is not a circle, the diameter is defined as a diameter whose area of circle is equal to that of the shape which is not a circle, so that V_o is calculated in the same manner as described above.

A golf ball according to the present invention has dimples of such a shape that V_o calculated in this manner has a value from 0.35 to 0.43, and more preferably from 0.37 to 0.41, and by using a golf ball wherein the

dimples having V_o from 0.35 to 0.43 represent not less than 90 percent, more preferably not less than 95 percent, and most preferably 100 percent of the whole dimples or the ball, so that the carry to the ball can be increased.

Different cross sectional shapes of dimples of golf balls according to the present invention are illustrated in FIGS. **8**, **9** and **10**, and V_o of the cross sectional dimple shape is 0.35 in FIG. **8**, 0.40 in FIG. **9** and 0.43 in FIG. **10**.

It should be noted that a value of V_o of dimples of conventional golf balls is greater than 0.45, and particularly around 0.50. For example, V_o of the dimple of a cross section of the parabolic curve of FIG. **2** is 0.50, V_o of the dimple of the elliptic cross section of FIG. **3** is 0.52 and V_o of the sinusoidal cross section of FIG. **4** is 0.46. While an inverted cone and an inverted pyramid may also be possible as the shape of conventional dimples, V_o of such dimples is 0.33, and hence a golf ball having such dimples is inferior in carry to a ball according to the present invention.

A dimple shape according to the present invention is such that a depthwise intermediate portion of a circumferential wall of the dimple is rather thin compared with a conventional dimple shape having V_o greater than 0.45 where the maximum diameter of the plane and the maximum depth are identical between both dimples.

According to the present invention, while the value of V_o of dimples is within the range as described above, the shape of the dimple in plan is not limited to a particular certain one. For example, while a shape of a dimple in plan is preferably a circle, it can be any other shape such as a polygon or the like. Moreover, while the maximum diameter and the maximum depth of a dimple are not limited to a certain particular value, preferably the maximum diameter is 2 to 4 mm and the maximum depth is 0.1 to 0.4 mm.

In addition, a golf ball according to the present invention preferably has from 280 to 330 dimples. An arrangement of dimples may be any of conventional patterns, and a suitable arrangement such as, for example, a right icosahedron arrangement or a right dodecahedron arrangement may be employed. Preferably, dimples are distributed on the surface of the ball in accordance with such an arrangement.

Dimple shapes according to the present invention can be applied to any type of golf balls such as small balls having a diameter of not less than 41.15 mm and a weight of not more than 45.92 g and large balls having a diameter of not less than 42.67 mm and a weight of not more than 45.92 g and can increase the carry of a ball. Further, while the dimple shapes can be applied to balls of any construction and hence to two piece sold balls, thread-wound balls and so on, particularly where the dimple shapes are applied to two piece solid balls, the increase in carry is remarkable. Besides, while conventional two piece solid balls generally have a low initial spin and hence they hardly produce a sufficient dynamic lift, a sufficient dynamic lift can be obtained by a golf ball which employs dimples according to the present invention.

The present invention makes it possible to reduce the problem a two piece solid golf ball experiences with regard to trajectory, i.e., its tendency to "drop" due to a small "lift".

The present invention will now be described more particularly in connection with the examples and comparative examples illustrated in the drawings, but it is to

be noted that the present invention is not limited to those specific examples as described below.

EXAMPLES AND COMPARATIVE EXAMPLES

Two piece solid balls (large size) having dimples of a circular shape in plan as indicated in Table 1, and ionomer cover thread-wound balls (large size) having dimples as indicated in Table 1 were produced as mentioned below, and using a hitting robot produced by True Temper Company, hitting tests were performed to evaluate the carries of the balls. It should be noted that the dimples were distributed uniformly over the entire surface of any ball.

Two piece solid ball	
Core	
Formulation:	
Cis-1,4-polybutadiene rubber	100 parts by weight
Zinc dimethacrylate	30 parts by weight
Zinc oxide	18 parts by weight
Dicumyl peroxide	2.5 parts by weight
Diameter: 38.1 mm	
Weight: 33.5 g	
Cover	
Formulation:	
Surlyn ® 1707 which is a trade name and sold by Du pont of the U.S.A.	100 parts by weight
Titanium dioxide	1 parts by weight
Thickness: 2.3 mm	

The core composition was vulcanized for 30 minutes at 160° C. in a mold to produce a solid core. Then the solid core was covered with the cover composition, followed by press molding for 2 minutes at 170° C. in a mold to obtain a two piece solid ball having a diameter of 42.7 mm, a weight of 45.2 g and a hardness (PGA compression) of 100.

Thread-wound ball	
Center	
Formulation:	
Cis-1,4-polybutadiene rubber	100 parts by weight
Sulfur	5 parts by weight
Zinc oxide	10 parts by weight
Barium sulfate	68 parts by weight
Vulcanization accelerator	1 parts by weight
Accelerator aid	3 parts by weight
Diameter: 30.0 mm	
Weight: 20.0 g	
Rubber thread	
Formulation:	
Cis-1,4-polyisoprene rubber	100 parts by weight
Sulfur	1 parts by weight
Zinc oxide	0.6 parts by weight
Vulcanization accelerator	1.5 parts by weight
Accelerator aid	1 parts by weight
Cover	
Formulation:	
Surlyn ® 1557 which is a trade name and solid by Du pont of the U.S.A.	100 parts by weight
Titanium oxide	1 parts by weight
Thickness: 2.0 mm	

The center composition was vulcanized for 20 minutes at 150° C. and the rubber thread composition was vulcanized for 40 minutes at 150° C. Then the center was wound with the rubber thread and thereafter covered with the cover composition, followed by press molding for 10 minutes at 160° C. to obtain an ionomer cover thread-wound ball having a diameter of 42.7 mm,

a weight of 45.2 g and a hardness (PGA compression) of 90.

Results of the tests of the two piece solid balls are indicated in Table 2 and in FIG. **13** while results of the tests of the thread-wound balls are indicated in Table 2 and in FIG. **14**.

It should be noted that the results of carries are average values of the results of 20 hits.

TABLE 1

Dimple Construction of Solid Two Piece and Thread Wound Balls

No.	Dimple Number	Dimple Diameter (mm)	Dimple Depth (mm)	V_o	Cross Sectional Shape	
1	318	3.84	0.24	0.35	FIG. 8	Example
2	318	3.83	0.23	0.40	FIG. 9	Example
3	318	3.76	0.25	0.43	FIG. 10	Example
4	318	3.52	0.25	0.50	FIG. 11	Comparative Example
5	318	3.73	0.24	0.53	FIG. 12	Comparative Example
6	318	3.75	0.24	0.50	FIG. 2	Prior Art
7	318	3.75	0.24	0.52	FIG. 3	Prior Art
8	318	3.75	0.24	0.46	FIG. 4	Prior Art

The arrangement of the dimples is shown in FIG. **15**.

TABLE 2

No.	V_o	Results: Two Solid Piece Ball Carry (m)	Results: Thread-wound Ball Carry (m)	
1	0.35	217	210	Example
2	0.40	220	211	Example
3	0.43	218	210	Example
4	0.50	213	206	Comparative Example
5	0.53	207	197	Comparative Example
6	0.50	212	205	Prior Art
7	0.52	209	199	Prior Art
8	0.46	215	205	Prior Art

From those results, it can be seen that a golf ball having dimples wherein V_o ranges from 0.35 to 0.43 provides a sufficiently large carry.

The invention being thus described, it will be obvious that the same may be varied in many ways. Such variations are not to be regarded as a departure from the spirit and scope of the invention, and all such modifications as would be obvious to one skilled in the art are intended to be included within the scope of the following claims.

What is claimed is:

1. A golf ball having a plurality of recessed dimples on the surface thereof, wherein said dimples have a shape wherein the value of the spatial volume of each dimple below a plane defined by an edge of the dimple divided by the volume of a cylinder wherein the bottom of said cylinder is defined by said plane and the height is determined by the maximum depth of the dimple from said plane, is within the range from 0.35 to 0.43, wherein the maximum diameter of the dimple is within the range of 2–4 mm and the maximum depth of the dimple is within the range of 0.1–0.4 mm, said dimples representing at least 90 percent of the total number of dimples on said golf ball.

2. A golf ball according to claim **1** wherein the value of the spatial volume of the dimple divided by the volume of the cylinder, is within the range from 0.37 to 0.41.

3. A golf ball according to claim **1** wherein the shape of the dimple in plan is a circle.

4. A golf ball according to claim **1** wherein the total number of the dimples is within the range from 280 to 330.

5. A golf ball according to claim **1** wherein the golf ball is a two piece solid ball.

6. A golf ball having a plurality of recessed dimples which in plan view have a circular shape, wherein the value of V_0 of said dimples ranges from 0.35 to 0.43, wherein V_0 is determined by the method comprising the steps of:

drawing an imaginary spherical face **2** of the diameter of the ball above a dimple **1** as illustrated in FIGS. **5** and **6**;

drawing another spherical face **3** having a smaller diameter by 0.16 mm then the ball diameter;

determining cross points **4** between the spherical face **3** and the dimple **1**;

drawing a line of cross points **6** between tangential lines **5** at the cross points **4** and the imaginary spherical face **2** to define a define a dimple edge **7**;

calculating a first volume V_1 of a dimple space **9** below a plane **8** defined by the dimple edge **7** by the following equation:

$$V_1 = \int_0^{\frac{Dm}{2}} 2\pi xydx;$$

calculating a volume V_2 of a cylinder **10** wherein the bottom thereof is defined by the plane **8** and the height is defined by the maximum dimple depth Dp from the plane **8** by the following equation:

$$V_2 = \frac{\pi Dm^2 Dp}{4};$$

and

calculating V_0 by the following equation:

$$V_0 = V_1/V_2,$$

said dimples representing at least 90% of the total number of dimples on said golf ball.

7. The golf ball according to claim **6**, wherein V_0 ranges from 0.37 to 0.41.

8. The golf ball according to claim **6**, wherein the maximum diameter of the dimple ranges from 2 to 4 mm and the maximum depth of the dimple ranges from 0.1 to 0.4 mm.

9. The golf ball according to claim **6**, wherein the total number of dimples ranges from 280 to 300.

10. The golf ball according to claim **6**, wherein the golf ball is a two piece solid ball.

* * * * *

EXHIBIT 3

United States Patent [19]

Hamada et al.

[11] **Patent Number: 4,929,678**

[45] **Date of Patent: May 29, 1990**

[54] **RUBBER COMPOSITION AND A SOLID GOLF BALL OBTAINED THEREFROM**

[75] Inventors: **Akihiko Hamada,** Kakogawa; **Hidenori Hiraoka,** Kobe; **Yoshinobu Nakamura,** Nishinomiya; **Hiroshi Ohtsuru,** Akashi, all of Japan

[73] Assignee: **Sumitomo Rubber Industries, Ltd.,** Hyogo, Japan

[21] Appl. No.: **143,768**

[22] Filed: **Jan. 14, 1988**

[30] **Foreign Application Priority Data**

May 2, 1987 [JP] Japan 62-109147

[51] **Int. Cl.**[5] **C08F 8/42**

[52] **U.S. Cl.** **525/193;** 525/236; 525/237; 525/274; 525/301

[58] **Field of Search** 525/274, 301, 193, 236, 525/237

[56] **References Cited**

U.S. PATENT DOCUMENTS

4,056,269	11/1977	Pollitt et al.	525/274
4,305,851	12/1981	Tominaga et al.	525/274
4,770,422	9/1988	Isaac	525/274

OTHER PUBLICATIONS

"European H CIS", Aoyama and Partners, Technical Brochure.

Primary Examiner—Bernard Lipman
Attorney, Agent, or Firm—Birch, Stewart, Kolasch & Birch

[57] **ABSTRACT**

A rubber composition for a solid golf ball comprising a rubber component containing at least 40% by weight of a polybutadiene rubber which has a Mooney viscosity [ML_{1+4}(100° C.)] of 45 to 90 and a cis-1,4 bond of at least 80%, a co-crosslinking agent and a peroxide.

16 Claims, No Drawings

RUBBER COMPOSITION AND A SOLID GOLF BALL OBTAINED THEREFROM

FIELD OF THE INVENTION

The present invention relates to a rubber composition for a solid golf ball and a solid golf ball obtained therefrom.

BACKGROUND OF THE INVENTION

A solid golf ball is a golf ball excepting a thread wound golf ball in which thread rubbers are wound on a core and covered. The solid golf ball includes a one piece solid golf ball obtained by one piece molding and a usual solid golf ball consisting of a solid core and a resin cover. The usual solid golf ball generally includes a two piece solid golf ball of which solid core is obtained by one piece molding, and a multipiece solid golf ball of which solid core comprising a center core and one or more layers coated thereon. The solid golf ball at least contains a resilient portion obtained by vulcanizing a rubber composition.

The rubber composition for the solid golf ball contains a base rubber (such as polybutadiene rubber) and a co-crosslinking agent (such as a monomer having an unsaturated bond, for instance, a metal salt of an unsaturated carboxylic acid and the like). The co-crosslinking agent is grafted or crosslinked to the polybutadiene chain by the function of a peroxide polymerization initiator to form a three dimensional structure of the polybutadiene and the monomer. The three dimensional structure imparts a necessary hardness, rebound properties and durability to the obtained solid golf ball.

Although the obtained golf ball has tolerable properties, it is further required for a golf ball to have higher rebound coefficient and durability. Improvement of rebound coefficient and durability has been made by means of an amount of the co-crosslinking agent, an amount of the peroxide and a vulcanizing temperature and the like. However, no golf balls perfectly meeting these the requirements have been obtained yet.

For further improvement of rebound properties and durability, the inventors have studied in view of raw materials, especially the base rubber, i.e. polybutadiene. It has been found that a high cis-polybutadiene rubber having a Mooney viscosity of at least 45, preferably 50 to 70 enhances the rebound properties and durability of the solid golf ball as long as it has the same hardness. This cis-polybutadiene rubber has a higher molecular weight than a conventional high cis-polybutadiene rubber which has a Mooney viscosity of 35 to 45. On the other hand, when the high cis-polybutadiene has a high Mooney viscosity, it adversely affects workability in mixing, molding etc, so as to result in poor quality with regard to stability of golf balls. It is surprising that high cis-polybutadiene rubber having a high Mooney viscosity does not deteriorate workability and simultaneously accomplishes an improvement in physical properties, if the polybutadiene rubber has a dispersity (dispersity=weight average molecular weight (Mw)/number average molecular weight (Mn)) of 4.0 to 8.0.

SUMMARY OF THE INVENTION

The present invention is to provide a rubber composition for a solid golf ball comprising a rubber component comprising at least 40% by weight of a polybutadiene rubber which has a Mooney viscosity [ML_{1+4}(100° C.)] of 45 to 90 preferably 50 to 70, and a cis-1,4 bond of at least 80%, a co-crosslinking agent, and a peroxide.

The present invention also provides solid golf balls formed from the rubber composition mentioned above.

DETAILED DESCRIPTION OF THE INVENTION

The polybutadiene rubber has a cis-1,4 bond content of at least 80%, preferably at least 95%. It also has a Mooney viscosity [ML_{1+4}(100° C.)] of 45 to 90, preferably 50 to 70, more preferably 55 to 65. A polybutadiene rubber having a Mooney viscosity of less than 45 is a conventional one and provides no improvement on the rebound properties and durability of the solid golf ball. If the polybutadiene has a Mooney viscosity of more than 90, dispersibility of the rubber composition becomes poor. In view of workability, it is preferred that the polybutadiene has a broad molecular weight distribution and a dispersity which is a ratio of weight average molecular weight (Mw)/number average molecular weight (Mn) within the range of 4.0 to 8.0, preferably 4.0 to 6.0. Dispersities of less than 4.0 deteriorate workability, and dispersities of more than 8.0 improve workability but decline the physical properties of the golf ball.

In addition to the polybutadiene, the rubber component (a) may contain the other rubber, for example, adiene type rubber, such as styrene-butadiene rubber, polyisoprene rubber, natural rubber and the like. An amount of the other rubber is less than 60% by weight, preferably less than 10% by weight based on the total weight of the rubber component (a).

In the present invention, the co-crosslinking agent (b) encompasses an unsaturated carboxylic acid and a metal salt thereof. Examples of the co-crosslinking agents are acrylic acid, methacrylic acid, a divalent metal salt thereof (such as zinc acrylate and zinc methacrylate), and a mixture thereof. The co-crossliking agent is present in the rubber composition of the present invention in an amount of 15 to 60 parts, preferably 25 to 40 parts by weight based on 100 parts by weight of the rubber component (a).

The peroxide (c) can be one which is generally used in this field. Representative examples of the peroxides are an organic peroxide, such as dicumyl peroxide, t-butylperoxybenzoate and di-t-butylperoxide; and the like. Dicumyl peroxide is preferred. The peroxide can be present in the rubber composition in an amount of 0.5 to 3.0 parts by weight, preferably 1.0 to 2.5 parts by weight based on 100 parts by weight of the rubber component.

A golf ball is standardized by JIS S-7005-1955 to a diameter of at least 42.67 mm for large size or at least 41.15 mm for small size, and a weight of not more than 5.9. A specific gravity of the golf ball is inevitably determined. In order to meet the standard, the rubber composition generally contains a filler, such as barium sulfate, zinc oxide, calcium carbonate, silica and the like. Also, an additive, such as antioxidant and the like may be added to the rubber composition to improve the properties of the golf ball.

The rubber composition of the present invention can be prepared by mixing the above components by means of a roll or a kneader. Mixing conditions are known to a skilled in the art. Generally, mixing is carried out for 10 to 30 minutes, preferably 15 to 25 minutes, at a temperature of 50° to 140° C., preferably 70° to 120° C.

The solid golf ball includes, as mentioned hereinbefore, a one piece solid golf ball, a two piece solid golf ball and a multipiece solid golf ball. The one piece solid golf ball can be prepared by vulcanizing the rubber composition of the present invention through one piece molding. The two and multi- piece solid golf ball is generally composed of a solid core and a resin cover. In case of the multipiece solid golf ball, the solid core is composed of a center core and one or more outer layers coated thereon. At least a portion of the solid core is prepared by vulcanizing the rubber composition of the present invention. Vulcanizing is conducted at a temperature of 140° to 170° C. for 20 to 40 minutes in a mold. The resin cover is one generally used for golf balls, preferably it is an ionomer resin which is available from Mitsui Polychemical Company under a trade name of Himilan 1707, 1706 and 1605. A combination of the ionomer resin can be employed. The ionomer resin can be blended with another resin.

The solid golf ball of the present invention has superior rebound properties and fatigue resistance in comparison with a golf ball employing a conventional butadiene rubber. Poor workability which is brought about from an elevated Mooney viscosity can be improved by adjusting the dispersity (Mw/Mn).

EXAMPLES

The present invention is illustrated by the following examples, which are not to be construed as limiting the invention to their details.

EXAMPLES 1 to 5 AND COMPARATIVE EXAMPLES 1 to 3

Physical and chemical properties of polybutadiene rubbers used in the Examples are listed in Table 1.

TABLE 1

	Mooney viscosity[1] ML_{1+4}(100° C.)	Micro structure[2] (%) Cis 1,4	Trans 1,4	Vinyl	Average Weight[3] Mn	molecular Mw	Dispersity Mw/Mn
A	55	96	2.5	1.5	12.5×10^4	75×10^4	6.0
B	60	96	2	2	15×10^4	75×10^4	5.0
C	55	95.5	3	1.5	13×10^4	74×10^4	5.7
D	62	96	2.5	1.5	18×10^4	68.5×10^4	3.8
E	43	96	2	2	9.8×10^4	47×10^4	4.8
F	40	96	2	2	9.7×10^4	44×10^4	4.5
G	42	96	2	2	9.0×10^4	76×10^4	8.5
H	75	96	2.5	1.5	21.0×10^4	85.1×10^4	4.1

A polybutadiene as shown in Table 1, zinc acrylate, zinc oxide and dicumyl peroxide were mixed using a roll in amounts shown in Table 2 and molded at 145° C. for 40 minutes to obtain a solid core having a diameter of 38.5 mm. The solid core was covered with a resin cover containing 100 parts by weight of an ionomer resin available from Mitsui Polychemical Company as Himilan 1707 and 2 parts by weight of titanium oxide to obtain a two piece large solid golf ball. The solid golf ball was subjected to a test on compression, coefficient of restitution and durability index and the result was shown in Table 2.

TABLE 2

		Examples 1	2	3	4	5	Comparative Example 1	2	3
Solid	Butadienerubber								
core	A	100							
ingre-	B		100						
dients	C			100					
(parts	D				100				
by	E						100		
weight)	F							100	
	G								100
	H					100			
	Zinc acrylate	31	31	31	31	31	31	31	31
	Zinc oxide	22	22	22	22	22	22	22	22
	Dicumyl peroxide	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
	Antioxidant[1]	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Roll mixing properties[2]		Good	Good	Good	Fairy good	Fairy good	Good	Good	Good
Ball	Compression[3]	103	104	103	105	105	103	102	102
proper-	Coefficient	0.792	0.795	0.792	0.794	0.795	0.782	0.781	0.780
ties	of restitution[4]								
	Durability index[5]	120	130	120	125	125	100	100	97

EXAMPLES 6 to 10 AND COMPARATIVE EXAMPLES 4 to 6

Ingredients as shown in Table 3 were mixed using a roll in amounts shown in Table 3 and molded at 170° C. for 25 minutes to obtain a large, one piece solid golf ball. The solid golf ball was subjected to a test on compression, coefficient of restitution and durability index and the result was shown in Table 3.

TABLE 3

		Examples					Comparative Example		
		6	7	8	9	10	4	5	6
Solid core ingredients (parts by weight)	Butadienerubber								
	A	100							
	B		100						
	C			100					
	D				100				
	E						100		
	F							100	
	G								100
	H					100			
	Methacrylic Acid	25	25	25	25	25	25	25	25
	Zinc oxide	25	25	25	25	25	25	25	25
	Dicumyl peroxide	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Roll mixing properties		Good	Good	Good	Fairy good	Fairy good	Good	Fairy good	Good
Ball properties	Compression	92	92	90	93	93	90	90	88
	Coefficient of restitution	0.715	0.720	0.715	0.718	0.720	0.705	0.706	0.698
	Durability index	118	125	118	123	123	100	100	95

What is claimed is:

1. A rubber composition for a solid golf ball having excellent durability and rebound properties comprising:

(a) a rubber component comprising at least 40% by weight of a polybutadiene rubber which has a Mooney viscosity $\{ML_{1+4}(100^\circ\ C.)\}$ of 50 to 70 and a cis-1,4 bond content of at least 80%,

(b) a co-crosslinking agent, and

(c) a peroxide.

2. The rubber composition according to claim 1 wherein the polybutadiene rubber has a dispersity of 4.0 to 8.0, wherein dispersity is the weight average molecular weight (Mw) divided by the number average molecular weight (Mn).

3. The rubber composition according to claim 1 wherein the rubber component is a mixture of said polybutadiene rubber and another diene type rubber.

4. The rubber composition according to claim 1 wherein the co-crosslinking agent is zinc acrylate.

5. The rubber composition according to claim 1 wherein the peroxide is dicumyl peroxide.

6. The rubber composition according to claim 2 wherein the rubber component is a mixture of said polybutadiene rubber and another diene type rubber.

7. The rubber composition according to claim 6, wherein the co-crosslinking agent is zinc acrylate.

8. The rubber composition according to claim 7 wherein the peroxide is dicumyl peroxide.

9. The rubber composition according to claim 1 wherein said polybutadiene rubber has a Mooney viscosity of 55 to 65.

10. The rubber composition according to claim 8 wherein said polybutadiene rubber has a Mooney viscosity of 55 to 65.

11. The rubber composition according to claim 1 wherein the polybutadiene rubber has a dispersity of 4.0 to 6.0.

12. The rubber composition according to claim 8 wherein the polybutadiene rubber has a dispersity of 4.0 to 6.0.

13. The rubber composition according to claim 10 wherein the polybutadiene rubber has a dispersity of 4.0 to 6.0.

14. The rubber composition according to claim 1 wherein said rubber component (a) comprises less than 60% by weight of a rubber other than the polybutadiene rubber, wherein said co-crosslinking agent (b) is present in an amount of 15 to 60 parts by weight based on 100 parts by weight of said rubber component (a), and wherein said peroxide (c) is present in an amount of 0.5 to 3.0 parts by weight based on 100 parts by weight of said rubber component (a).

15. The rubber composition according to claim 2 wherein said rubber component (a) comprises less than 10% by weight of a rubber other than the polybutadiene rubber, wherein said co-crosslinking agent (b) is present in an amount of 25 to 40 parts by weight based on 100 parts of said rubber component (a), and wherein said peroxide (c) is present in an amount of 1.0 to 2.5 parts by weight based on 100 parts by weight of said rubber component (a).

16. The rubber composition according to claim 8 wherein said polybutadiene rubber has a cis-1,4 bond content of at least 95%, wherein said rubber component (a) comprises less than 60% by weight of a rubber other than the polybutadiene rubber, wherein said co-crosslinking agent (b) is present in an amount of 15 to 60 parts by weight based on 100 parts by weight of said rubber component (a), and wherein said peroxide (c) is present in an amount of 0.5 to 3.0 parts by weight based on 100 parts by weight of said rubber component (a).

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 4,929,678

DATED : May 29, 1990

INVENTOR(S) : Akihiko HAMADA et al.

Page 1 of 2

It is certified that error appears in the above-indentified patent and that said Letters Patent is hereby corrected as shown below:

Inserting at column 4, line 56 below Table 2:

-- 1 Available from Yoshitomi Pharmaceutical Company as Yoshinox 425.

2 Roll mixing properties: Total evaluation on roll winging conditions, dispersibility of the composition and surface conditions of a blank sheet.

Good: No problems on the above check points.

Fairly good: No problem on dispersibility of the composition, but winding conditions are bad and surface conditions are very rough.

Bad: Every check point is bad.

3 Compression according to PGA expression.

4 Calculated from an initial velocity when a metal cylinder of 198.4 g was collided with a ball at 45 m/s at 23 °C.

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 4,929,678

DATED : May 29, 1990

INVENTOR(S) : Akihiko HAMADA et al.

It is certified that error appears in the above-indentified patent and that said Letters Patent is hereby corrected as shown below:

5 An index of number of collisions until a ball is broken when it is repeatedly collided with an impact board at 45 m/s, which is calculated by converting Comparative Example 1 to 100.--.

Signed and Sealed this

Twenty-ninth Day of July, 1997

Attest:

Bruce Lehman

BRUCE LEHMAN

Attesting Officer

Commissioner of Patents and Trademarks

EXHIBIT 4

United States Patent [19] [11] Patent Number: 5,009,428
Yamagishi et al. [45] Date of Patent: Apr. 23, 1991

[54] **GOLF BALL**

[75] Inventors: **Hisashi Yamagishi; Shinichi Kakiuchi,** both of Yokohama; **Seisuke Tomita,** Tokorozawa, all of Japan

[73] Assignee: **Bridgestone Corporation,** Tokyo, Japan

[21] Appl. No.: **517,730**

[22] Filed: **May 2, 1990**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 435,207, Nov. 4, 1989.

[30] **Foreign Application Priority Data**

Dec. 2, 1988 [JP] Japan 63-305561

[51] **Int. Cl.^{5}** **A63B 37/12**
[52] **U.S. Cl.** **273/232;** 40/327
[58] **Field of Search** 273/232; 40/327

[56] **References Cited**

U.S. PATENT DOCUMENTS

4,844,472 7/1989 Ihara 273/232

Primary Examiner—George J. Marlo

[57] **ABSTRACT**

A golf ball having at least three types of dimples arranged in a specific distribution pattern has improved aerodynamic symmetry and offers consistent flying performance. Three phantom orthogonal great circles are drawn on the spherical surface of the ball to define eight spherical regular triangles, and phantom perpendiculars are extended from the three apexes of each spherical regular triangle to the opposite sides to divide the spherical regular triangle into six equal spherical right triangles, thereby dividing the entire spherical ball surfaces into 48 equal spherical right triangles.

dimples are arranged on every two adjoining spherical right triangles such that the dimples are in axial symmetry with respect to the common side of the two adjoining spherical right triangles and the dimples do not intersect the great circles.

4 Claims, 4 Drawing Sheets

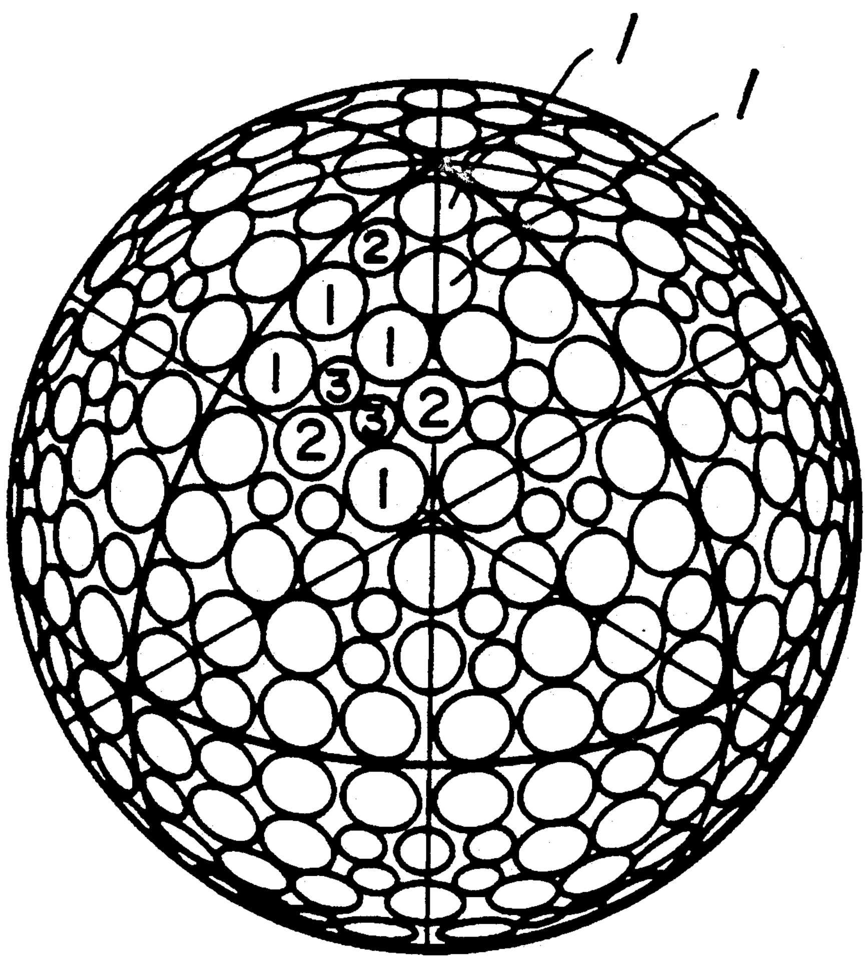


FIG. 1

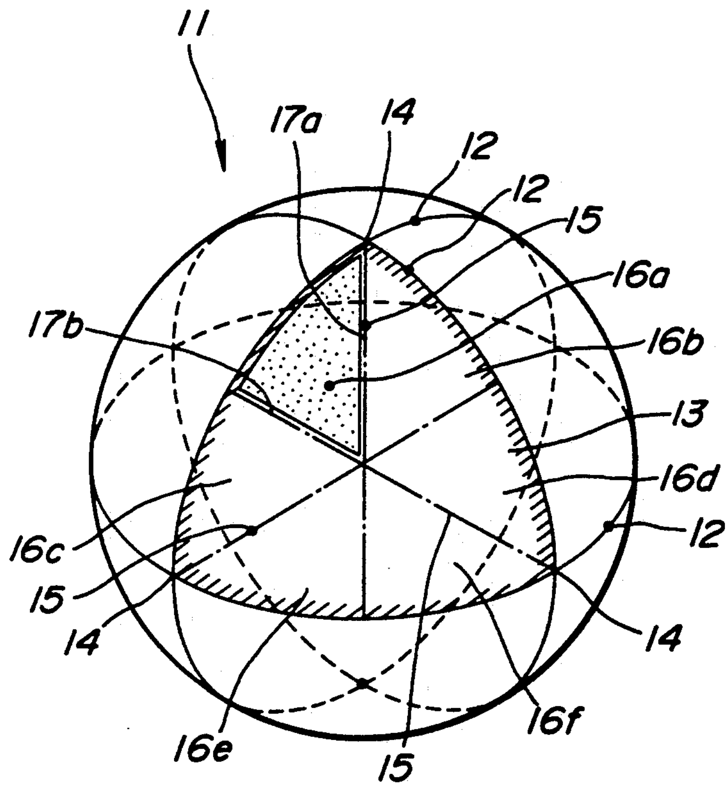


FIG. 2

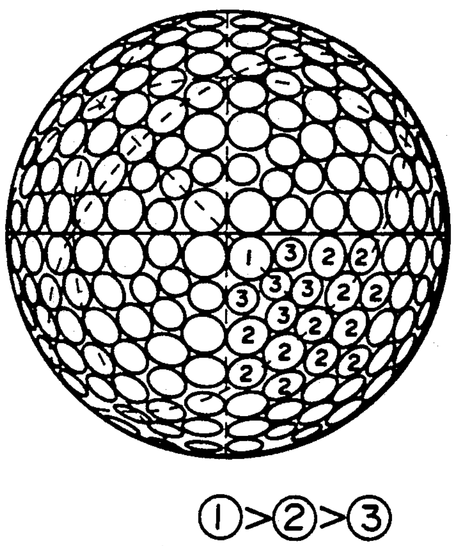


FIG. 3

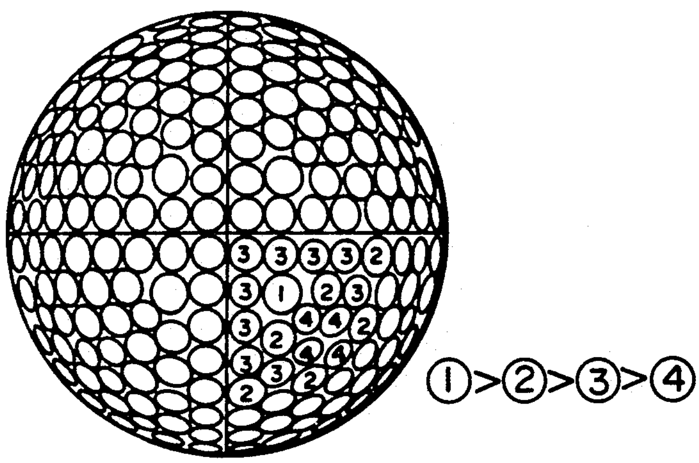


FIG.4

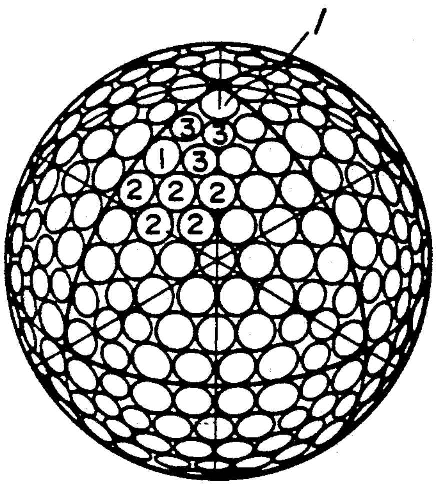


FIG.5

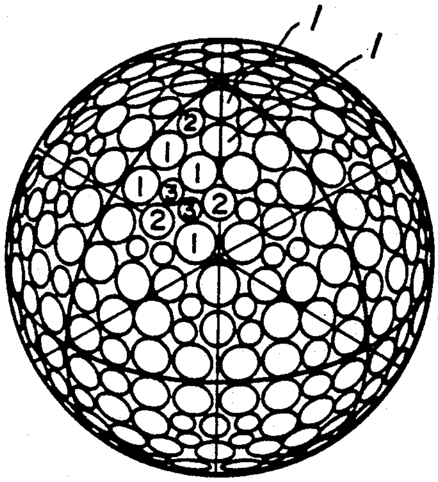


FIG.6

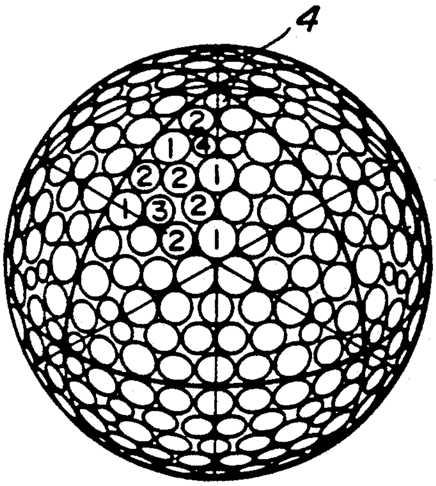


FIG.7

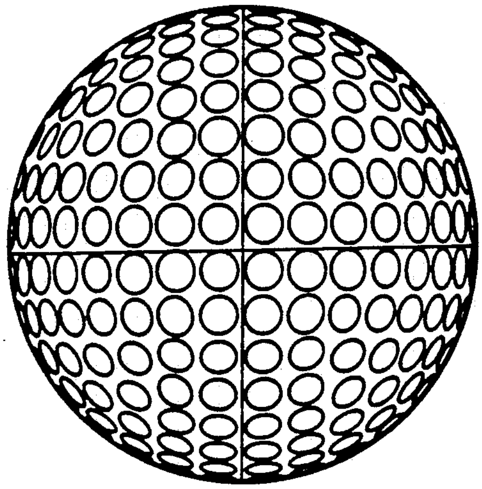


FIG. 8

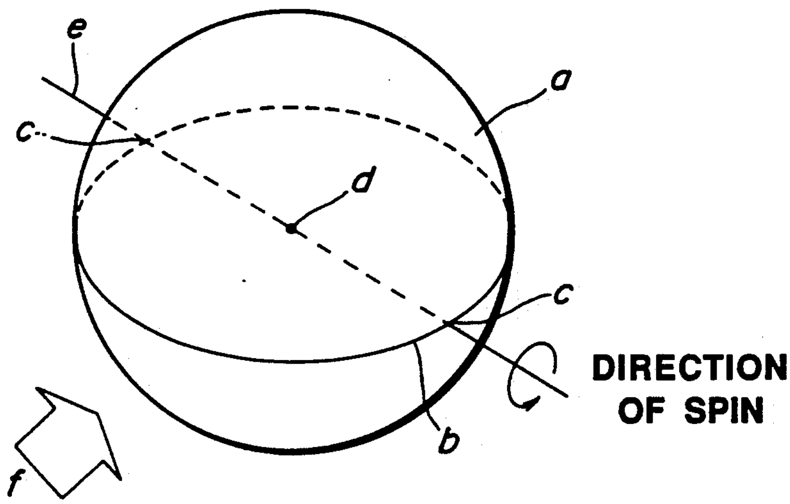
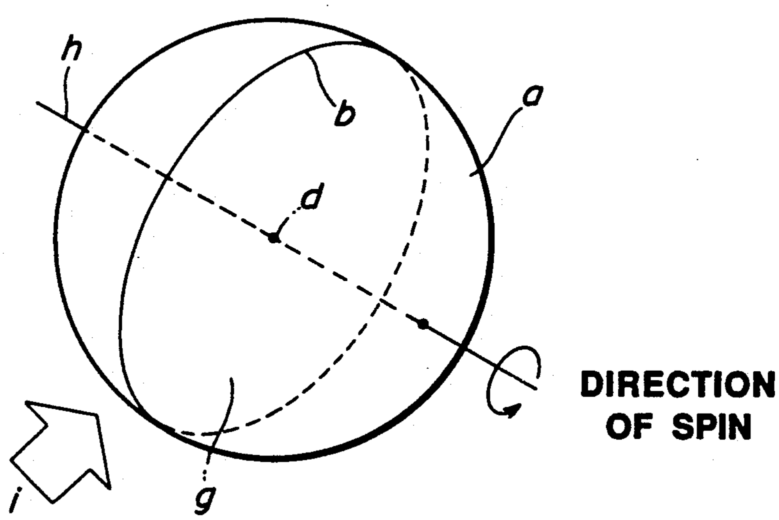


FIG. 9



GOLF BALL

CROSS REFERENCE TO RELATED APPLICATION

This is a continuation-in-part application of copending application Ser. No. 07/435,207 filed Nov. 9, 1989.

This invention relates to golf balls having dimples properly distributed for aerodynamic symmetry and thus exhibiting consistent flying performance.

BACKGROUND OF THE INVENTION

Golf balls are required to meet aerodynamic symmetry as prescribed in Professional Golfers' Association Rule, for example, Japan Professional Golfers' Association Rule, Appendix III, Ball (C). It is required that when hit under given conditions, a ball give essentially no difference in trajectory and distance irrespective of different hitting positions.

Currently commercially available golf balls are considered to meet the required aerodynamic symmetry as long as the prescription is concerned, but tend to give a slight difference in trajectory and distance depending on a particular hitting position. If balls are aerodynamically asymmetric, then such asymmetry, though quite slight, would cause inconsistent shots especially for skilled players and professional golfers.

One of the causes for aerodynamically asymmetric golf balls is the presence of a seam line. Since golf balls are most often manufactured by compression molding in mated mold halves each having a semispherical molding surface, a seam line is formed at the mating line between the mold halves as a great circle with which none of the dimples intersect. Therefore, seam lines are inevitably present on golf balls for the manufacture reason.

The ball hitting test prescribed in Japan, UK or US Professional Golfers' Association Rule, Appendix III, Ball (C) is now described in detail. Referring to FIGS. **8** and **9**, a golf ball a is shown as having a center d and a seam line b. Two hitting tests are prescribed, that is, a hitting test of FIG. **8** called pole hit where the golf ball a is hit at f so as to produce a back spin about a diametrical line e connecting three points, two diametrically opposite points c and c on the seam line b and the center d, and a hitting test of FIG. **9** called seam hit where the golf ball a is hit at i so as to produce a back spin about a diametrical line h extending perpendicular to a circular plane g having a circumference coincident with the seam line b and passing through the center d. The aerodynamic symmetry of the ball is evaluated in terms of differences in carry distance, peak angle (the angle of a straight line connecting the maximum point the ball reaches and the ground location where the ball is hit with respect to the horizontal line), and flight time between the two hitting tests. It is known for golf balls having a seam line that in these hitting tests, the balls given a pole hit assume a trajectory having a larger peak angle than in the case of a seam hit, resulting in a difference in carry distance and flight time.

It was proposed to improve the aerodynamic symmetry of a ball by providing on the ball surface a plurality of great circles which do not intersect the dimples as the seam line does not. One example is an icosahedral distribution which is achieved by equally dividing the ball surface into 20 triangles of a regular 20-sided (icosahedral) body and distributing dimples in each of the triangles. There were proposed several similar golf balls having a high degree of geometrical uniformity. Room for improvement is left in such geometrically uniform golf balls.

SUMMARY OF THE INVENTION

Therefore, an object of the present invention is to provide a golf ball having improved aerodynamic symmetry and thus exhibiting consistent flying performance.

Briefly stated, the present invention pertains to a golf ball having at least three types of dimples on the surface thereof. The present invention assumes that the ball has a phantom spherical surface, three phantom orthogonal great circles are drawn on the spherical surface to define eight spherical regular triangles, and phantom perpendiculars are extended from the three apexes of each said spherical regular triangle to the opposite sides to divide the spherical regular triangle into six equal spherical right triangles, thereby dividing the entire spherical right surface into 48 equal spherical right triangles. Dimples are arranged on every two adjoining spherical right triangles in axial symmetry with respect to the common side of the triangles such that the dimples may not intersect the great circles.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects, features, and advantages of the present invention will be better understood from the following description taken in conjunction with the accompanying drawings, in which:

FIG. **1** is a geometrical illustration of a golf ball, showing the dimple distribution of the invention;

FIGS. **2** and **3** are plan views showing different distribution patterns of dimples on golf balls;

FIGS. **4** to **6** are plan views showing further embodiments of the invention;

FIG. **7** is a plan view of the golf ball used in Comparative Example; and

FIGS. **8** and **9** illustrate how to evaluate the aerodynamic symmetry of a golf ball.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. **1**, there is illustrated the geometry of a golf ball designated at **11**. The ball **10** has a phantom spherical surface. Three phantom orthogonal great circles **12**, **12**, **12** are drawn on the spherical surface to define eight spherical regular triangles **13**, **13**, . . . so that the spherical ball surface is equally divided into eight sections. Phantom perpendiculars **15**, **15**, **15** are extended from the three apexes **14**, **14**, **14** of each said spherical regular triangle **13** to the opposite sides to divide the spherical regular triangle **13** into six equal spherical right triangles ***16a***, ***16b***, ***16c***, ***16d***, ***16e***, ***16f***, thereby dividing the entire spherical ball surface into 48 equal spherical right triangles. Dimples of three or more types (not shown in FIG. **1**) are arranged on each of these spherical right triangles. More particularly, dimples are arranged on every two adjoining spherical right triangles (for example, ***16a*** and ***16b***, ***16a*** and ***16c*** and so on) in axial symmetry with respect to the common side between the triangles (for example, common side ***17a*** between ***16a*** and ***16b***, common side ***17b*** between ***16a*** and ***16c***, and so on). The dimples do not intersect the great circles **12**, **12**, **12**. It should be understood that one of the great circles **12**, **12**, **12** can coincide with a seam line produced in the manufacture of a golf ball. The dimples can intersect the sides of the spherical right

triangles **16** except those sides coincident with the great circles **12, 12, 12**.

Illustrative distributions of dimples meeting the above-defined requirement are shown in FIGS. **2** and **3**. In FIG. **2**, three types of dimples **1, 2,** and **3** are arranged on every two adjoining spherical right triangles such that the dimples are in axial symmetry with respect to the common side between the triangles and the dimples do not intersect the great circles. In FIG. **3**, four types of dimples **1, 2, 3,** and **4** are similarly arranged. It is to be noted in FIGS. **2** and **3** that the area of dimples decreases in the order of their reference numeral, that is, dimples **1** have a larger area than dimples **2**, dimples **2** have a larger area than dimples **3**, and so on.

The dimples arranged in the spherical surface of a ball include three or more groups of dimples each preferably having a diameter in the range of from 2.7 to 4.4 mm, a depth in the range of from 0.15 to 0.24 mm, and a ratio of diameter to depth in the range between 10 and 35, more preferably between 13 and 25, though the invention is not limited thereto.

The dimples distributed on the golf ball of the invention are of at least three types as described above. Preferably, three, four or five types of dimples are arranged on the ball. The dimple type is distinguished in diameter and/or depth. In general, 360 to 560 dimples in total are distributed on the ball, and the percent area occupied by the dimples is preferably at least 70%, especially 70 to 90% of the entire ball surface (phantom spherical surface), ensuring further improved aerodynamic symmetry.

Preferred dimple arrangements are regular icosahedral, regular dodecahedral, and regular octahedral arrangements. The dimples may preferably be distributed uniformly on the ball surface according to any of the above-mentioned arrangements.

The golf balls of the invention may be embodied as solid golf balls including one- and two-piece golf balls and thread-wound golf balls. Their manufacture may be carried out by any desired conventional method.

The dimple design defined by the present invention may be applied to any type of golf ball including small balls having a diameter of at least 41.15 mm and a weight of up to 45.92 g, and large balls having a diameter of at least 42.67 mm and a weight of up to 45.92 g.

There has been described a golf ball having dimples arranged in a specific distribution pattern. The ball provides improved aerodynamic symmetry and a minimized difference in trajectory and distance due to different hitting positions, that is, different axes of back spin, thus offering consistent flying performance.

EXAMPLE

Examples of the invention are given below by way of illustration and not by way of limitation.

Examples 1-3 and Comparative Example

There were prepared two-piece balls of the large size (diameter 42.67 mm) using the core and the cover of the following formulation. Each ball had dimples whose dimension, number, and distribution pattern are shown in Table 1. Except the dimples, the remaining components were the same for all the balls.

Two-piece ball Composition	Parts by weight
Core	
Poly(cis-1,4-butadiene) rubber	100
Zinc dimethacrylate	30
Filler	appropriate
Peroxide	appropriate
Cover	
Ionomer resin (Surlyn ® 1707, E. I. duPont, Shore D hardness 68)	100
Titanium dioxide	1
Thickness: 2.3 mm	

The dimple distribution patterns used are shown in FIGS. **4** through **7**. In the figures, numeral **1** designates the largest dimples, **2** designates second largest dimples, and so forth.

The golf balls were evaluated for aerodynamic symmetry by the hitting test prescribed in PGA Rule, Appendix III, Ball (C). That is, aerodynamic symmetry was evaluated in terms of a difference in carry, total distance (carry plus run), and peak angle between the pole hit and the seam hit. The results are also shown in Table 1.

TABLE 1

	Example 1	Example 2	Example 3	Comparative Example
Dimples (circular)				
Dimple type (1)	4.20 × 0.205 mm 72	4.10 × 0.195 mm 216	4.10 × 0.185 mm 144	3.75 × 0.220 mm 336
type (2)	3.90 × 0.200 mm 192	3.60 × 0.170 mm 96	3.55 × 0.160 mm 216	—
type (3)	3.20 × 0.155 mm 120	2.50 × 0.120 mm 96	3.20 × 0.145 mm 48	—
type (4)	—	—	2.45 × 0.110 mm 72	—
Total dimple number	384	408	480	336
Distribution pattern	FIG. 4	FIG. 5	FIG. 6	FIG. 7
Surface occupied	74.4%	75.2%	83.3%	64.9%
Aerodynamic symmetry				
Carry, m	1.2	0.8	0.3	2.0
Total distance, m	1.5	1.1	0.7	4.0
Peak angle, °	0.08	0.07	0.03	0.2

*Dimple type is expressed in diameter (mm), depth (mm), and number, with the diameter and depth shown at the upper line and the number at the lower line.

As seen from Table 1, the golf balls of the invention have improved aerodynamic symmetry and offer consistent flying performance.

Although some preferred embodiments have been described, many modifications and variations may be made thereto in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described.

We claim:

1. A golf ball having at least three types of dimples on the surface thereof, wherein

provided that the ball has a phantom spherical surface, three phantom orthogonal great circles are drawn on the spherical surface to define eight spherical regular triangles, and phantom perpendiculars are extended from the three apexes of each said spherical regular triangle to the opposite sides to divide the spherical regular triangle into six equal spherical right triangles, thereby dividing the entire spherical ball surface into 48 equal spherical right triangles,

dimples are arranged on every two adjoining spherical right triangles such that the dimples are in axial symmetry with respect to the common side of the two adjoining spherical right triangles and the dimples do not intersect the great circles.

2. The golf ball of claim 1 wherein one of the great circles coincides with a seam line resulting from the ball manufacture.

3. The golf ball of claim 1 wherein three, four or five types of dimples are present.

4. The golf ball of claim 1 wherein 360 to 560 dimples are present in total.

* * * * *

EXHIBIT 5

US005087049A

United States Patent [19]

Yamagishi et al.

[11] **Patent Number: 5,087,049**

[45] **Date of Patent: Feb. 11, 1992**

[54] **GOLF BALL**

[75] Inventors: **Hisashi Yamagishi**, Yokohama; **Seisuke Tomita**, Tokorozawa, both of Japan

[73] Assignee: **Bridgestone Corporation**, Tokyo, Japan

[21] Appl. No.: **555,011**

[22] Filed: **Jul. 20, 1990**

[30] **Foreign Application Priority Data**

Jul. 25, 1989 [JP] Japan 1-193670

[51] **Int. Cl.**^{5} **A63B 37/12**

[52] **U.S. Cl.** **273/232**; 40/327

[58] **Field of Search** 273/232; 40/327

[56] **References Cited**

U.S. PATENT DOCUMENTS

4,681,323	7/1987	Alaki et al.	273/232
4,762,326	8/1988	Gobush	273/232
4,844,472	7/1989	Ihara	273/232
4,974,856	12/1990	Morell	273/232

Primary Examiner—George J. Marlo
Attorney, Agent, or Firm—Sughrue, Mion, Zinn Macpeak & Seas

[57] **ABSTRACT**

A golf ball with three dimples (14) having the same shape and an equal diameter and an equal depth are distributed about the center of each spherical regular triangle (13) such that three line segments connecting the centers of the three dimples (14) define a regular triangle (15). The length of each line segment, that is, length (D_{D1}) of one side of the regular triangle (15) does not exceed twice the diameter (D_m) of the dimples (14). No other dimples are located within the regular triangle (15) associated with the three dimples (14). Two dimples (16) having the same diameter as the three dimples (14) are distributed on each side of the spherical regular triangle (13) in symmetry with respect to its middle point such that the distance (D_{D2}) between the centers of the two dimples (16) does not exceed twice the diameter (D_m) of the dimples (16).

10 Claims, 6 Drawing Sheets

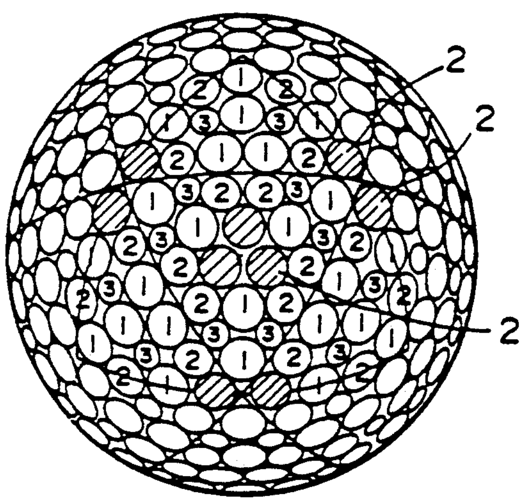


FIG.1

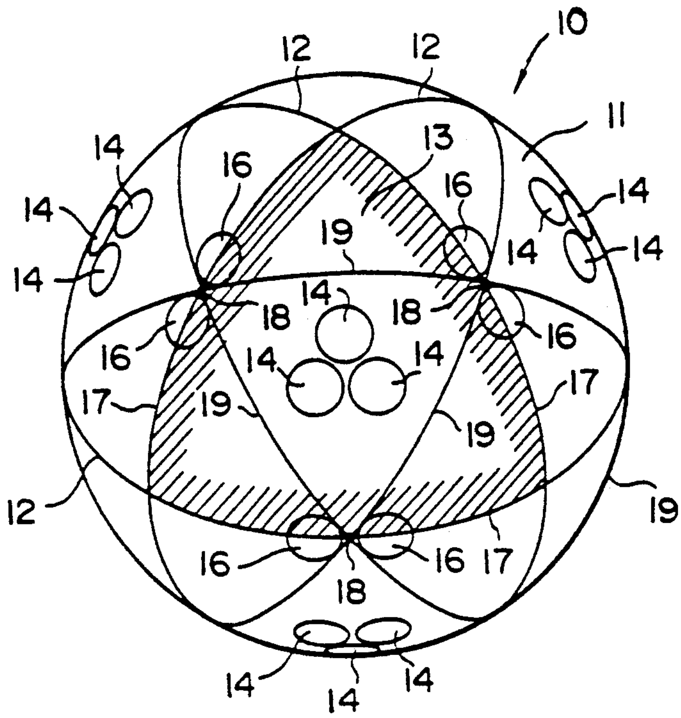

10
11
12
12
12
13
14
14
14
14
14
14
14
14
14
14
14
14
16
16
16
16
16
16
17
17
17
18
18
18
19
19
19
19
19

FIG.2

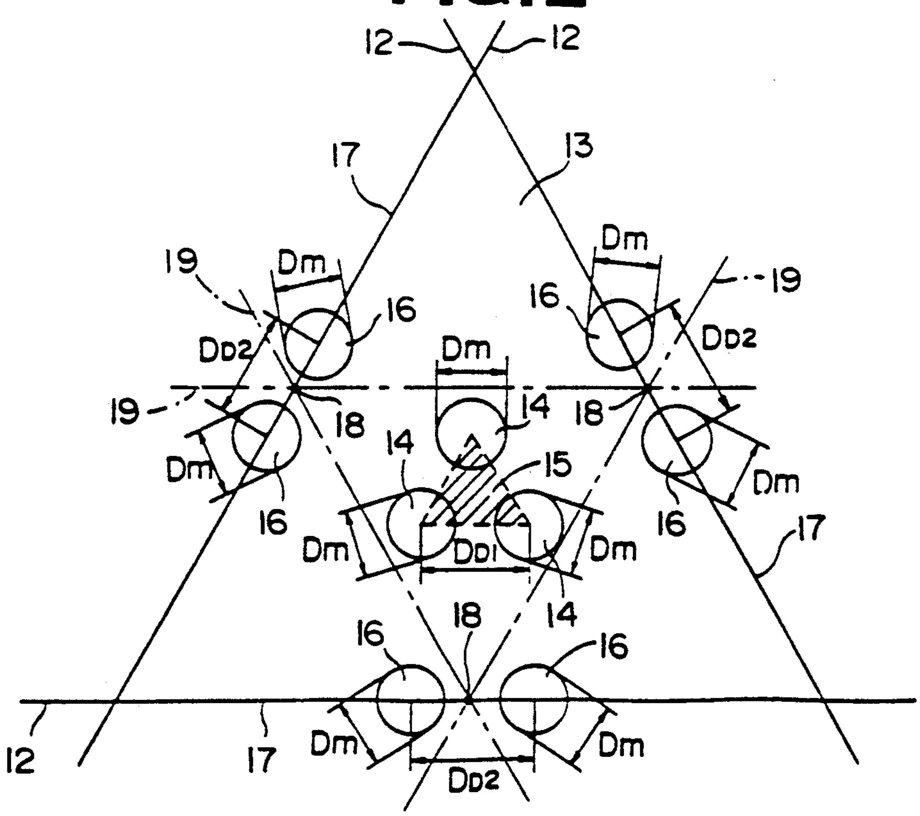

12
12
12
13
17
17
17
19
19
19
Dm
Dm
Dm
Dm
Dm
Dm
Dm
Dm
Dm
DD2
DD2
DD2
DD1
14
14
14
15
16
16
16
16
16
16
18
18
18

FIG. 3

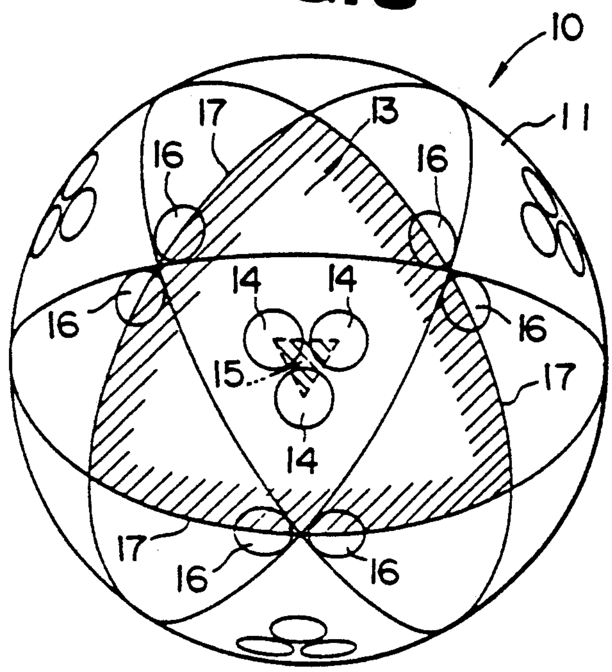

10
11
13
14
14
14
15
16
16
16
16
16
16
17
17
17

FIG. 4

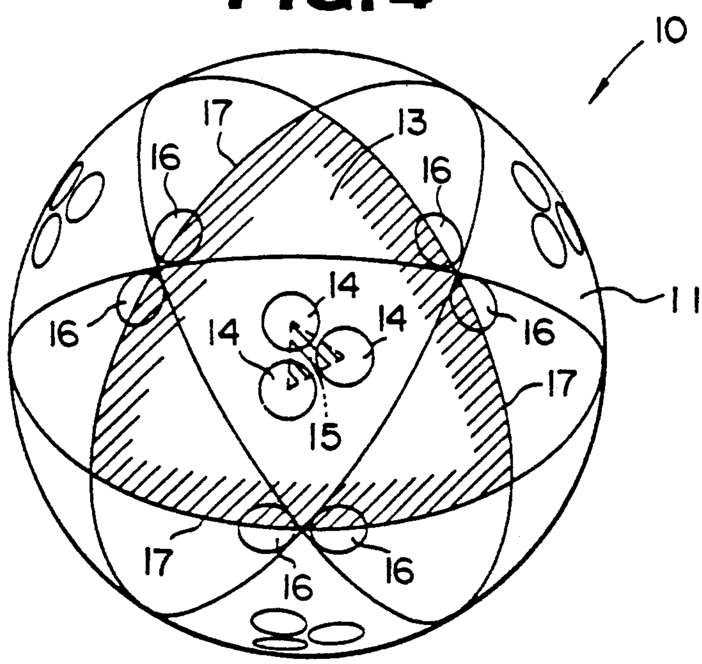

10
11
13
14
14
14
15
16
16
16
16
16
16
17
17
17

FIG. 5

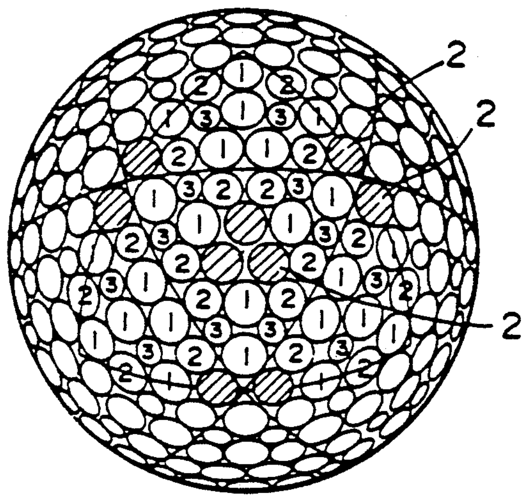


FIG. 6

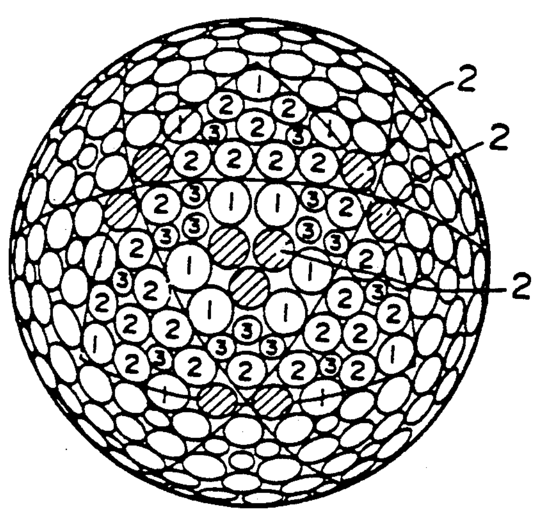


FIG. 7

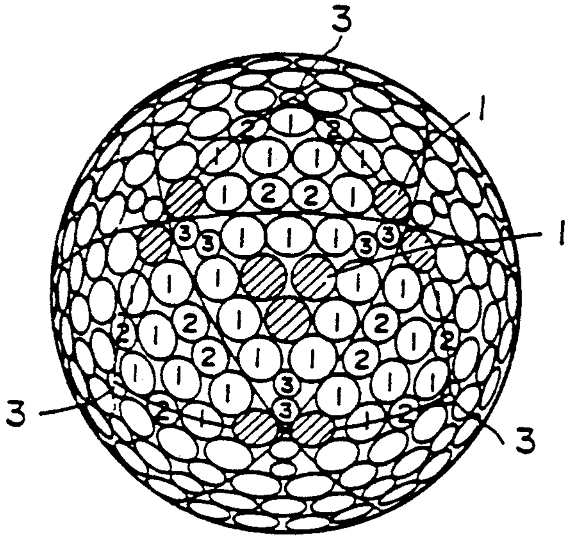


FIG. 8

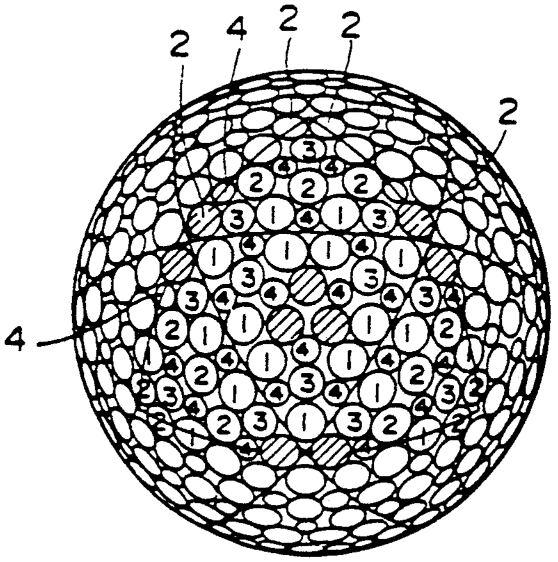


FIG. 9

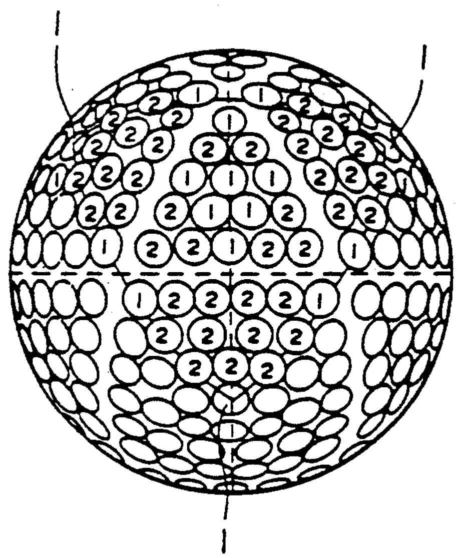


FIG. 10

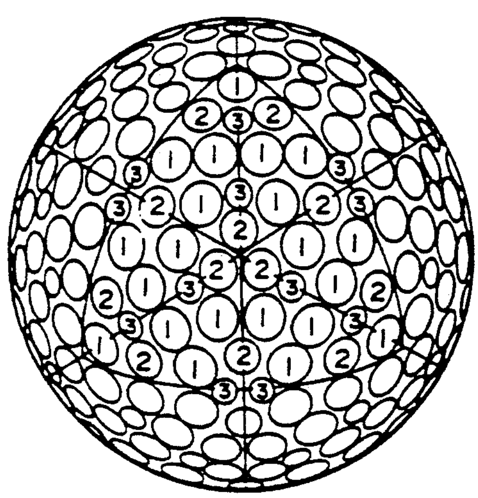


FIG.11

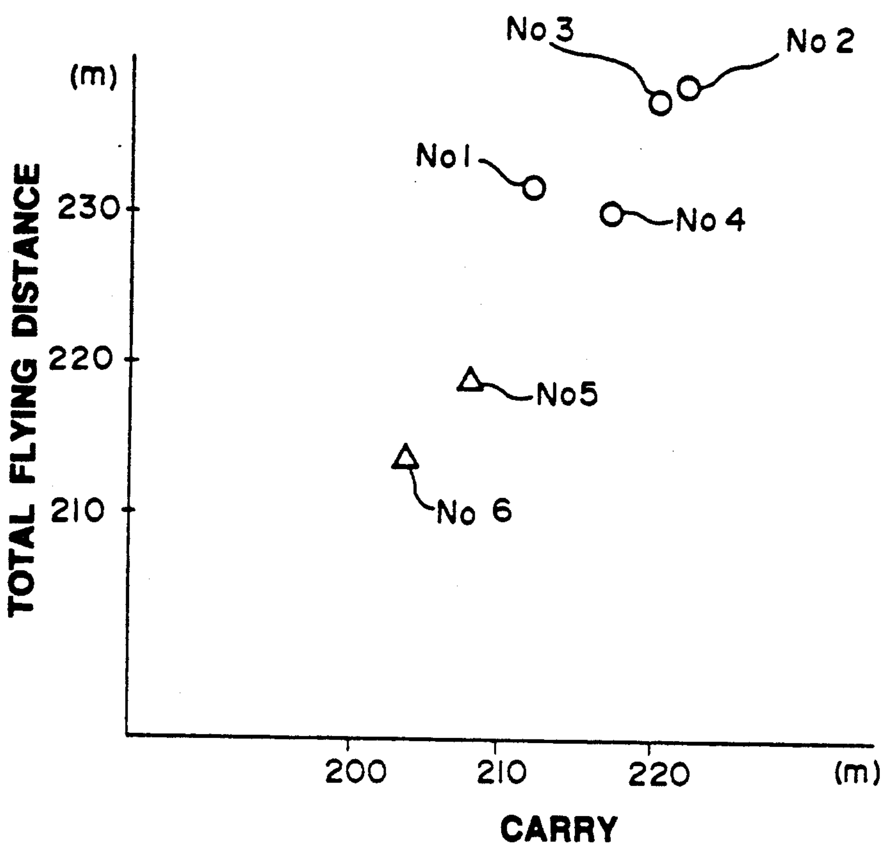
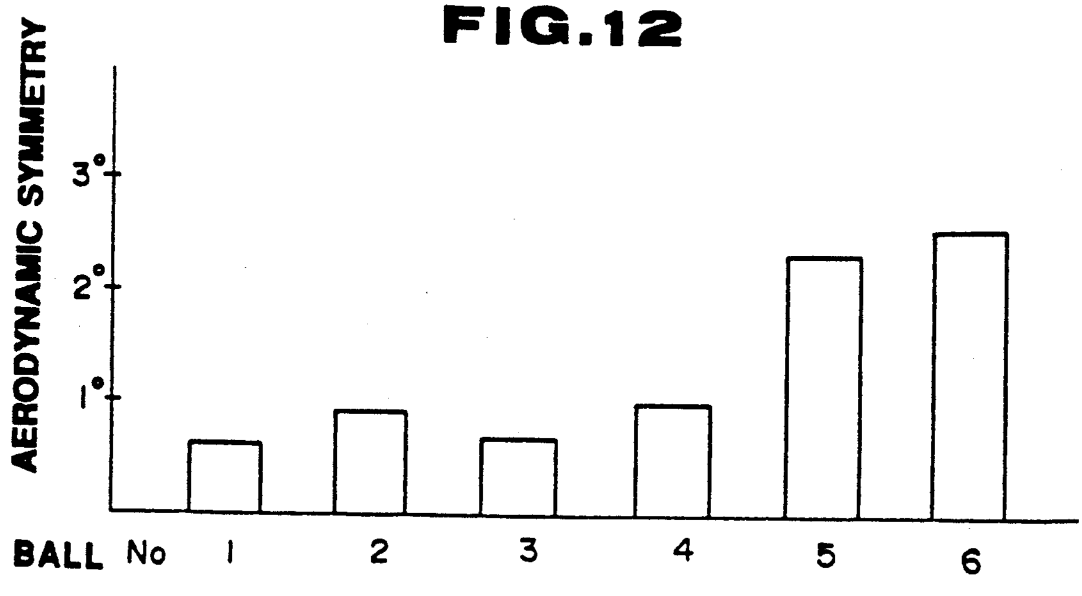

No 3
No 2
(m)
No 1
230
No 4
TOTAL FLYING DISTANCE
220
No5
210
No 6
200
210
220
(m)
CARRY

FIG.12


AERODYNAMIC SYMMETRY
3°
2°
1°
BALL No
1
2
3
4
5
6

GOLF BALL

This invention relates to golf balls having at least three groups of dimples distributed in a regular octahedral arrangement. More particularly, it relates to golf balls having an improved dimple arrangement ensuring improved aerodynamic symmetry and thus an increased flying distance.

BACKGROUND OF THE INVENTION

Golf balls are required to meet aerodynamic symmetry as prescribed in Professional Golfers' Association Rule, for example, the U.S. Golf Association Rule, Appendix III, Ball (C). It is required that when hit under given conditions, a ball has essentially no difference in trajectory and distance irrespective of different hitting positions.

In the conventional golf balls, dimples are distributed in symmetry with respect to a plurality of axes in order to accomplish aerodynamic symmetry. For instance, the phantom spherical surface of a golf ball is equally divided into planes of a regular hexahedral (6-sided), octahedral (8-sided), dodecahedral (12-sided) or icosahedral (20-sided) shape in which dimples are distributed. Among others, the regular icosahedral distribution wherein the ball surface is divided into equal 20 triangles of a regular icosahedron offers the maximum number of equally divided planes in equally dividing the spherical surface and has the maximum geometrical symmetry and the maximum number of symmetry axes, and is thus believed to provide improved aerodynamic symmetry. For this reason, various designs based on the regular icosahedral distribution have been proposed and implemented in practice.

Golf players have a consistent need for golf balls having improved flying performance. A variety of dimple arrangements have been proposed in order to improve flying performance, especially flying distance. Some golf balls whose dimple arrangement has improved flying performance, but less aerodynamic symmetry can be limited on use by the above-mentioned Rule. Therefore, the mainstream dimple arrangement is the regular icosahedral distribution.

However, other than the regular icosahedral distribution, regular octahedral and some other distributions are considered to provide dimple distributions having improved flying performance. There is a need for a regular octahedral or similar dimple distribution capable of meeting both the requirements of flying performance and aerodynamic symmetry.

SUMMARY OF THE INVENTION

Therefore, an object of the present invention is to provide a golf ball having a regular octahedral dimple distribution and providing improved flying performance and aerodynamic symmetry.

According to the present invention, there is provided a golf ball having at least three groups of dimples on the surface thereof. As a premise, the ball has a phantom spherical surface, three first phantom orthogonal great circles are drawn on the spherical surface to define eight equal spherical regular triangles, each spherical regular triangle being delimited by three sides and having a center and middle points on the three sides, and four second phantom orthogonal great circles are drawn on the spherical surface, each second phantom great circle connecting the middle points on two of the

three sides delimiting the spherical regular triangle. Three dimples having the same figure and an equal diameter and an equal depth are distributed about the center of each spherical regular triangle such that three line segments connecting the centers of the three dimples define a regular triangle and the length of each line segment, that is, one side of the regular triangle does not exceed twice the diameter of the dimples, with the proviso that no other dimples are located within the regular triangle associated with the three dimples. Two dimples having the same diameter as the three diinples are distributed on each side of the spherical regular triangle in symmetry with respect to its middle point such that the distance between the centers of the two dimples does not exceed twice the diameter of the dimples. None of the dimples intersect the second phantom great circles.

The above-defined dimple arrangement allows dimples of three groups to be evenly distributed on an average without local concentration of dimples of an equal diameter. This results in a golf ball having both improved aerodynamic symmetry and flying performance.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects, features, and advantages of the present invention will be better understood from the following description taken in conjunction with the accompanying drawings, in which:

FIGS. **1** and **2** are geometrical illustrations of a golf ball, showing the dimple distribution of the invention, FIG. **1** showing the entire spherical ball surface and FIG. **2** being an enlarged view of one spherical regular triangle;

FIGS. **3** and **4** are plan views showing different distribution patterns of dimples on golf balls according to the invention;

FIGS. **5** to **8** are plan views showing further embodiments of the invention;

FIGS. **9** and **10** are plan views showing dimple arrangements outside the scope of the invention;

FIG. **11** is a graph showing the flying performance of golf balls, Nos. 1 to 6; and

FIG. **12** is a graph showing the results of an aerodynamic symmetry evaluation test on golf balls, Nos. 1 to 6.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIGS. **1** and **2**, there is illustrated the geometry of a golf ball designated at **10**. The ball **10** has a phantom spherical surface **11**. Three first phantom orthogonal great circles **12**, **12**, and **12** are drawn on the spherical surface **11** to define eight spherical regular triangles **13**, **13**, ... so that the spherical ball surface **11** is equally divided into eight sections. Each spherical regular triangle **13** is delimited by three sides **17**, **17**, and **17** and has a center (not shown) and middle points **18** on the three sides **17**, **17**, and **17**. Four second phantom orthogonal great circles **19**, **19**, **19**, and **19** are then drawn on the spherical surface, each great circle **19** connecting the middle points **18** and **18** on two of the three sides **17**, **17**, and **17** delimiting the spherical regular triangle **13**.

At least three groups of dimples are distributed in conjunction with the spherical regular triangles **13**. Three dimples **14**, **14**, and **14** having the same figure and an equal diameter Dm and an equal depth are distributed about the center of each spherical regular triangle **13** such that three line segments connecting the centers

of the three dimples **14**, **14**, and **14** define a regular triangle **15** and each line segment, that is, one side of the regular triangle **15** has a length D_{D1} which does not exceed twice the diameter Dm of each dimple **14** (that is, $D_{D1} \leqq 2Dm$). No other dimples are located within the regular triangle **15** associated with the three dimples **14**, **14**, and **14**. Further, two dimples **16** and **16** having the same diameter Dm as the three dimples **14**, **14**, and **14** are distributed on each side **17** of the spherical regular triangle **13** in symmetry with respect to its middle point **18** such that the distance D_{D2} between the centers of the two dimples **16** and **16** does not exceed twice the diameter Dm of each dimple **16** (that is, $D_{D2} \leqq 2Dm$). None of the dimples intersect the great circles **19**, **19**, **19**, and **19**. The two dimples **16** and **16** have the same figure and an equal diameter. The two dimples **16** and **16** may have the same depth as or a different depth from the three dimples **14**, **14** and **14** although it is preferred that the two dimples **16** and **16** have the same depth as the three dimples **14**, **14** and **14**.

The three dimples **14**, **14**, and **14** arranged about the center of the spherical regular triangle **13** are not limited to the distribution shown in FIG. **1**, but either of the distributions shown in FIGS. **3** and **4** may be used instead. More particularly, in the FIG. **1** distribution, the sides of the inner regular triangle **15** associated with the three dimples **14**, **14**, and **14** are approximately parallel to the three sides **17**, **17**, and **17** of the outer spherical regular triangle **13**. In the FIG. **3** distribution, the inner triangle **15** is inverted from that of FIG. **2**. In the FIG. **4** distribution, the inner triangle **15** is rotated an angle about the center from that of FIG. **2**. This means that the orientation of the inner triangle **15** with respect to the outer triangle **13** is not critical.

It is understood that one of the great circles **19**, **19**, **19**, and **19** with which none of the dimples intersect can be the seam line which is created on golf balls during their manufacture at the interface between mating mold halves.

The golf ball of the invention includes at least three groups of dimples, preferably 3 to 6 groups of dimples. The dimples have a circular shape in a plan view, that is, when viewed in a radial direction with respect to the ball. The dimples of different groups are different in diameter and/or depth.

In a golf ball with n groups of dimples wherein n is a positive integer of at least 3, further improvements in flying distance and aerodynamic symmetry are achieved when the total dimple surface area quotient Dst is at least 4. The total dimple surface area quotient Dst is given by the following expression:

$$Dst = \frac{n \sum_{k=1}^{n} [(Dmk^2 + Dpk^2) \times Vok \times Nk]}{4R^2} \quad (1)$$

In the expression,

- Nk is the number of dimples belonging to each group k wherein k is 1, 2, 3, ..., and n,
- Dmk is the diameter of dimples belonging to group k,
- Dpk is the depth of dimples belonging to group k,
- R is the radius of the ball, and
- Vo is a value obtained by dividing the volume of the dimple space defined between the surface of a dimple k and a plane defined by the periphery of the dimple k by the volume of a cylinder having said plane defined by the periphery of the dimple k as its base and the maximum depth of the dimple k as its height. With respect to Vo, reference is made to Japanese Patent Application Kokai No. 163674/1985 (U.S. Pat. No. 4,681,323 or British Patent No. 2,153,690). Preferably Vo is in the range of from 0.3 to 0.6, especially 0.44 to 0.5 as an average of all the dimples.

In the dimple distributions of FIGS. **1** to **4**, the dimples **14** and **16** preferably have a larger diameter among the three or more groups, more preferably the largest or next-to-largest diameter. The diameter Dm of these dimples **14** and **16** is preferably in the range from 3.6 to 4.3 mm, more preferably from 3.65 to 4.1 mm. The dimples **14** and **16** preferably have a depth in the range of from 0.15 to 0.24 mm, more preferably from 0.16 to 0.21 mm. Further, the length D_{D1} of each side of the regular triangle **15** or between the dimples **14** centers preferably ranges from 3.6 to 8.6 mm, more preferably from 3.65 to 8.2 mm. Also the length D_{D2} between the dimples **16** centers is preferably in the range from 3.6 to 8.6 mm, more preferably from 3.65 to 8.2 mm.

The dimples of the other groups are evenly distributed on the eight spherical regular triangles **13**. In distributing at least three groups of dimples which are different in diameter and/or depth on the respective spherical regular triangles **13**, the number of dimples belonging to the same group is equal among the triangles **13**. Where at least three groups of dimples are arranged on each spherical regular triangle **13**, the dimples are uniformly distributed, that is, have the same distribution pattern with respect to a symmetrical axis which is a perpendicular from each apex of the triangle **13** to the opposing side. As previously described, the dimples do not intersect the second phantom great circles **19**, but some can intersect the first phantom great circles **12**. It is also permissible that some dimples position at the apexes of each spherical regular triangle **13**. The other dimples preferably have a diameter of 2.00 to 4.20 mm, more preferably from 2.30 to 4.00 mm and a depth of 0.15 to 0.24 mm, more preferably from 0.16 to 0.21 mm.

The golf ball of the invention generally bears 350 to 570 dimples, preferably 390 to 560 dimples in total. The total number of the specifically located dimples **4** and **6** is 48 since eight regular triangles are defined on the ball surface by three first phantom great circles. Then the number of the dimples **4** and **6** and dimples having the same shape is 48 or more. The proportion of the specifically located dimples is preferably 10 to 70%, more preferably 20 to 70% of the total dimples. When the specifically located dimples occupy 10 to 70% of the total dimples, the specifically located dimples are distributed such that more than two of them do not closely adjoin each other. Those dimples having the smallest diameter should preferably be 10 to 40% of the total dimples.

The dimple distribution defined by the present invention may be applied to any type of golf ball including solid golf balls such as one- and two-piece golf balls and thread-wound golf balls. The golf balls can be prepared by conventional techniques. It should be appreciated that the balls include both small balls having a diameter of at least 41.15 mm and a weight of up to 45.92 g, and large balls having a diameter of at least 42.67 mm and a weight of up to 45.92 g.

EXAMPLE

Examples of the invention are given below by way of illustration and not by way of limitation.

EXAMPLES 1-6

There were prepared two-piece golf balls of the large size (42.67 mm diameter). Each ball had dimples whose dimension, number, and distribution pattern are shown in Table 1. Except the dimples, the remaining components were the same for all the balls. The dimple distribution patterns used are shown in FIGS. 5 through 10. In the figures, numeral 1 designates the largest dimples, 2 designates second largest dimples, and so forth.

Examples 5 and 6 are outside the scope of the invention.

TABLE 1

Dimple groups				Overall dimples		
Example	Group	Dia. × Depth × Number	%	Vo	Dst	Pattern
1	1	4.05 mm × 0.215 mm × 240	55.6			
	2	3.45 mm × 0.190 mm × 96	22.2	0.480	4.54	FIG. 5
	3	2.60 mm × 0.155 mm × 96	22.2			
2	1	4.15 mm × 0.205 mm × 96	21.2			
	2	3.70 mm × 0.190 mm × 240	52.6	0.465	4.30	FIG. 6
	3	2.35 mm × 0.130 mm × 120	26.3			
3	1	4.10 mm × 0.210 mm × 240	67.7			
	2	3.60 mm × 0.185 mm × 96	18.5	0.450	4.24	FIG. 7
	3	2.50 mm × 0.145 mm × 96	13.8			
4	1	3.65 mm × 0.200 mm × 144	26.6			
	2	3.50 mm × 0.190 mm × 144	26.6	0.480	5.94	FIG. 8
	3	3.30 mm × 0.185 mm × 96	17.4			
	4	2.30 mm × 0.150 mm × 168	30.4			
5*	1	3.65 mm × 0.230 mm × 78	21.3			
	2	3.45 mm × 0.220 mm × 288	78.7	0.480	2.36	FIG. 9
6*	1	4.05 mm × 0.225 mm × 168	50.0			
	2	3.75 mm × 0.195 mm × 96	28.6	0.470	3.54	FIG. 10
	3	2.50 mm × 0.150 mm × 72	21.4			

*outside the scope of the invention

The balls were tested for flying performance, that is, carry and total flying distance (carry plus run) by hitting with a driver at a head speed of 45 m/sec. They were also evaluated for aerodynamic symmetry by the hitting test prescribed in USGA Rule, Appendix III, Ball (C).

The results are shown in FIGS. 11 and 12.

There has been described a golf ball having dimples properly located in a regular octahedral distribution such that aerodynamic symmetry and flying distance are increased at the same time.

Although some preferred embodiments have been described, many modifications and variations may be made thereto in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described.

We claim:

1. A golf ball having groups of dimples on the surface thereof, wherein

provided that the ball has a phantom spherical surface (11), three first phantom orthogonal great circles (12) are drawn on the spherical surface (11) to define eight equal spherical regular triangles (13), each spherical regular triangle (13) being delimited by three sides (17) and having a center and middle points (18) on the three sides (17), and four second phantom great circles (19) are drawn on the spherical surface (11), each second phantom great circle (19) connecting the middle points (18) on two of the three sides (17) delimiting the spherical regular triangle (13), each spherical regular triangle (13) having three segments of the second phantom great circles (19);

a group of three dimples (14) having the same shape and an equal diameter and an equal depth is distributed about the center of each spherical regular triangle (13) such that three line segments connecting the centers of the three dimples (14) define a regular triangle (15) and the length of each line segment (D_{D1}) of of one side of the regular triangle (15) does not exceed twice the diameter (Dm) of the dimples, and not other dimples are located within the regular triangle (15) associated with the three dimples (14),

a group of two dimples (16) having the same diameter as the three dimples (14) is distributed on each side of the spherical regular triangle (13) in symmetry with respect to its middle point such that the distance (D_{D2}) between the centers of the two dimples (16) does not exceed twice the diameter (Dm) of the dimples (16),

and none of the dimples intersect the second phantom great circles (19).

2. The golf ball of claim 1 wherein one of the second phantom great circles coincides with a seam line resulting from the ball manufacture.

3. The golf ball of claim 1 wherein 350 to 570 dimples are present in total.

4. The golf ball of claim 1 wherein said golf ball has 6 groups of dimples.

5. The golf ball of claim 4 wherein a total dimple surface area quotient Dst is at least equal to 4, where:

$$Dst = \frac{n \sum_{k=1}^{n} [(Dmk^2 + Dpk^2) \times Vok \times Nk]}{4R^2} \quad (1)$$

In the expression,

Nk is the number of dimples belonging to each group k wherein k is 1, 2, 3, ... and n,

Dmk is the diameter of dimples belonging to group k,

R is the radius of the ball, and

Vo is a value obtained by dividing the volume of the dimple space defined between the surface of a dimple k and a defined by the periphery of the dimple k by the volume of a cylinder having said plane defined by the periphery of the dimple k as its base

and the maximum depth of the dimple k as its height.

6. The golf ball of claim 1 wherein said diameter Dm of said dimples is in the range of 3.6 to 4.3 mm.

7. The golf ball of claim 1 wherein the length of each line segment D_{D1} is in the range of 3.6 to 8.6 mm.

8. The golf ball of claim 1 wherein the length of each line segment D_{D2} is in the range of 3.6 to 8.6 mm.

9. The golf ball of claim 1 wherein said golf ball is solid.

10. The golf ball of claim 1 wherein said golf ball is thread wound.

* * * * *

CERTIFICATE OF SERVICE

I certify that on May 16, 2007 I electronically filed the foregoing with the Clerk of the Court using CM/ECF, which will send notification of such filing(s) to Richard L. Horwitz and David E. Moore.

I further certify that I caused copies to be served upon the following on May 161, 2007 in the manner indicated:

BY E-MAIL & HAND

Richard L. Horwitz, Esquire
POTTER ANDERSON & CORROON LLP
1313 N. Market Street
Wilmington, DE 19801

BY E-MAIL & FEDERAL EXPRESS

Joseph P. Lavelle, Esquire
HOWREY LLP
1299 Pennsylvania Avenue, NW
Washington, DC 20004

/s/ Leslie A. Polizoti

Leslie A. Polizoti (#4299)
MORRIS, NICHOLS, ARSHT & TUNNELL LLP
Wilmington, DE 19801
(302) 658-9200
lpolizoti@mnat.com